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Transportation and Other Constraints Relating to the Development of Mineral Resources in the Canadian North

by

Jacqueline Amelie Staveley ©

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of Master of Science

in

Mining Engineering

Department of Mining, Metallurgical and Petroleum Engineering

Edmonton, Alberta

Fall 1995

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled *Transportation and other constraints relating to the development of mineral resources in the Canadian North* submitted by *Jacqueline Amelie Staveley* in partial fulfillment of the requirements for the degree of *Master of Science* in *Mining Engineering*.

Supervisor: I. R. Muirhead

J. M. Whiting

L. R. Plitt

L. R. Riiett

Date: August 24th 1995

Dedicated to Mother Earth

The ultimate provider and source of all mineral wealth

ABSTRACT

The Canadian North contains a wealth of mineral resources which have historically contributed to the economic development of the area. A major factor in the feasibility of current and potential resource operations is the availability of reliable and economic transportation of supplies and products. Transportation is the key that will unlock the mineral resources of the North, where large centres are few, population small, travel distances large and travel alternatives limited. Mining has played a major part in the colonization of the North, and therefore in the development of transportation networks.

This study examines the relationship between mineral development and other factors: transportation, environment, socioeconomic and economic factors. The effects of these factors on mineral development are evaluated.

The responsible development of mineral resources can provide an economic means by which the North can take control of the future. This development can best be achieved through cooperation of all parties involved.

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CHAPTER 1: INTRODUCTION

Introduction to the North.

The North is many things to many people. The term 'north' is a subjective one, its meaning depends upon the perspective of the observer. There are many descriptions and classifications of the north of Canada, each based on features obvious or useful to the classifier. Some frequently used boundaries are:

the southern limit of discontinuous permafrost

the 0°C isotherm (mean annual air temperature)

60°N latitude

the southern limit of the boreal forest

These boundaries are artificial and imposed by paradigm or politics. For the purposes of this study, the term 'North' refers to the territorial norths, i.e. the Northwest Territories and Yukon, i.e. the area north of 60°N (Figure 1.1). The reason for this is that different administrative systems exist within the territorial and provincial norths. The administrative differences (discussed below) have had a major impact on the developmental policies and practices employed. The author recognizes that many developmental issues are continuous across the 60th parallel, this will be addressed where appropriate.

The North contains over 40% of Canada's land area, but less than 0.5% of its population. The total population of the NWT is 64,600 (NWT Bureau of Statistics, Oct. 1994) and the population of Yukon is 31,300 (Yukon Bureau of Statistics, Dec. 1994). Much of the non-Native population (39% in the NWT, 86% in Yukon) is concentrated in the territorial capitals of Yellowknife (pop. 15,179) and Whitehorse (pop. 22,900).

Figure 1.1 Area covered by this study, the Territorial North.

Climate in the North is defined as Arctic[1] or Subarctic[2]. In summer the days are long and sunny, with average July temperatures in the range 0° to 20°C. In winter the days are short, with average January temperatures between -20° and -38°C. The climate and geology of the North are shown on Figure 1.2. The major geological regions of the North are the Canadian Shield, the Great Plains and the Cordilleran and Innuitian Orogens. Permanently frozen ground (permafrost) underlies much of the North, its depth and continuity is a function of latitude, climate and topography. The mildest climate exists in the Cordillera and Mackenzie River Valley. In this area, trees are abundant and form the northern boreal forest, which continues south of the 60th parallel. The northern limit of trees (the 'treeline') swings southwards across the Canadian Shield, where relief is low and abundant lakes are found. North of the boreal forest is the Arctic tundra, characterized by low, ground-hugging vegetation, little precipitation and high winds.

The government of Yukon and Northwest Territories is divided between the Federal and Territorial Governments. Federal control of the Territories is much greater than for the Provinces of Canada. Recent changes in government structure have given the Territorial Governments greater control over the North, but many aspects, including mineral resources, are still controlled by the Federal Government. Recent land claim settlements between First Nations and the Government of Canada have altered the administration of

[1] In the Arctic, mean air temperature for the warmest month is less than 10°C, mean annual air temperature is less than 0°C (Bone, 1992). Air temperature is measured under standard conditions 6 feet above the ground surface. The Arctic is divided further into Arctic and High Arctic by some climatologists.

[2] The Sub-Arctic is the region having a mean air temperature greater than 0°C in the coldest month, a mean air temperature greater than 10°C for the warmest month, but less than 4 months with a mean air temperature of greater than 10°C.

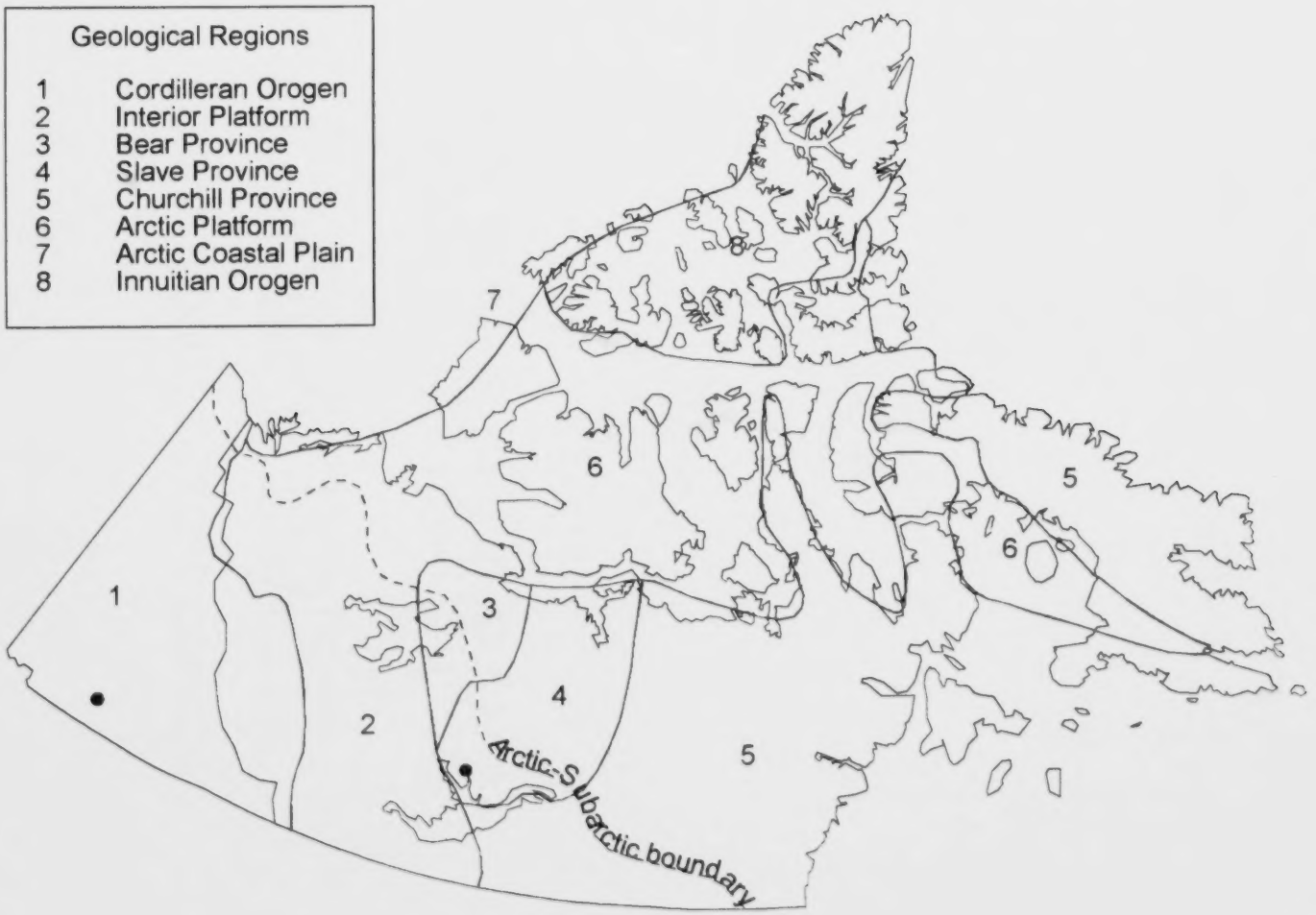

Figure 1.2 Climate and major geologic regions in the North of Canada.

parts of the North. The full effects of these changes are not yet known, since many changes are still underway, and the political and administrative situation at present is dynamic.

A major change in the administrative structure of the Northwest Territories will take effect in 1999, as a result of the Nunavut Settlement Agreement (INAC, 1993). This agreement, between Canada and the Inuit people in the Eastern Arctic, is the largest aboriginal land settlement in Canadian history. The Northwest Territories will be divided into two new Territories, with the eastern territory to be known as Nunavut, as shown in Figure 1.3. Nunavut will have a majority Inuit population, and will be governed largely by Inuit. Many aspects of the Nunavut administration are not yet finalized, thus the full effects of division are unknown. Businesses located within the Nunavut Settlement Area are consulting with Inuit organizations to effect a smooth transition from one administration to the next. Further effects of the Nunavut settlement are discussed in Chapter 5. The western portion of the Northwest Territories has not been subject to such a comprehensive land claim.

Northern industry

Through much of its history, Canada has relied on its natural resources, for subsistence and trading activities prior to European contact, and for colonial and international trade after contact. In fact it was the rich fur and whaling trade and promises of mineral resources that made the land so attractive to Europeans, beyond the search for a Northwest Passage to India and the Orient. The North of Canada retains much of that dependence on resource industries to the present day. The main wage-earning industries in the North are mining, forestry, construction,

Figure 1.3 · The Nunavut Territory settlement area.

trapping and Native handicrafts. Many people in the larger centres are employed by the government. In more traditional Native settlements, a number of people are employed in subsistence economies, which are difficult to catalogue and describe financially in dollar terms.

Northern transportation

Northern transportation relies dominantly on air, road, rail and water networks. Most transportation is highly dependent on the weather, and many transportation routes and systems are confined to particular seasons.

Figure 1.4 shows the all-weather road network in the North. In the Northwest Territories this is limited to the southern area around Great Slave Lake, and the Mackenzie River Valley. A more extensive network exists in Yukon Territory, where soil conditions and community locations are generally more suitable for road building. A network of winter roads connects other NWT communities from November to late May, and also allows for winter resupply of some mining areas.

The Mackenzie River system provides a summer barge route. The route is available from spring break-up of ice to fall freeze-up. Supplies travel to Hay River by road or to Tuktoyaktuk by sea to enter the barge system. During the summer, marine transportation serves communities located along the shores of the Arctic Ocean and Hudson Bay. The shipping season is short; icebreakers can begin navigation in late May, and operate until November.

Communities which are not served by the road network are only accessible by air when shipping is not possible. Air transportation is also utilized by mining companies for transport of personnel in and out of the mine. Camp-style operations fly employees in and out on a rotation basis,

Figure 1.4 The Northern all-season road network.

using commercial or private flights. During certain seasons, supplies to the mine must also be flown in, which is costly. Careful planning ensures that supplies are brought in by other means where possible.

Mining in the North, a brief introduction.

Since the arrival of Europeans in the North, mining has played a part in Northern industry. Much European exploration of the north has stemmed directly from the search for mineral wealth, and many government centres are situated in mining districts. The NWT territorial capital of Yellowknife began its days as a mining settlement on the shores of Great Slave Lake, and Dawson City, home of the Klondike gold rush, was the administrative centre for Yukon Territory until the 1950's.

Mining in the north has extracted many different commodities through its history. The earliest efforts targeted precious metals, primarily gold, but also silver and radium. Other mineral products from the North over time include copper, lead, zinc, asbestos, uranium, coal and tungsten. Mining remains one of the primary Northern industries today, with production including gold, silver, lead and zinc.

Mining and the Northern economy

Mining has played a leading role in the economy of non-Native northerners throughout the settlement of the North. Much of the present Northern infrastructure owes its existence to past or present mining operations. Mining accounts for a large proportion of the GDP of the North, in good years second only to the Federal Government. In 1993, the value of mineral production in the North (excluding fuels) was $520 million, 17% of the Northern GDP. The total

value of mineral production in Canada for 1993 was $13,083 million, approximately 2% of the national GDP.

While some of the profit generated by the resource industries remains in the North, investment by southern Canadian and foreign companies often results in a flow of profits away from the region. This is a clear example of pecuniary benefits from mining, some benefit at the expense of others, on a national or international level. The 'expense' in such cases is represented by the disbenefits of living close to mineral activity: e.g. loss of land, environmental problems. Although programs are now underway to ensure improved participation by Northerners in industrial developments, many workers are still flown in on temporary contracts, and add very little to the local economic base. Another problem faced by Northern industry is the integration of modern industry with traditional native lifestyles and land-based economies. Such economies are difficult to quantify in dollar terms, which has led to an underestimation of their importance to an individual community and to the North as a whole.

Economic growth and development.

Figures in the previous section show how the mineral industry has contributed to the economic growth of the North. Economic growth may be defined as an increase in per capita income of a country or region. For any project, two types of benefits exist: total benefits from the project over a period of time, and distribution of wealth among geographic or demographic groups. It is this last type of benefit which causes contention over development projects in an area, including the North. Major lifestyle differences between the different cultures of the North result in different value sets. The large aboriginal population in

the North results in major demographic and cultural differences between groups of residents. Economic growth itself is not seen as desirable by all these groups. This presents a challenge to the mineral industry and to government: to derive maximum benefit for all Northern residents from mineral development in the North.

Transportation project evaluation.

Transportation planning and evaluation is the process by which transportation decisions are made. These decisions affect the development of transportation networks.

Economic analysis of transportation proposals is not a simple process. Basic evaluation techniques can be used, including cost/benefit analysis, rate of return studies etc. but values need to be carefully defined. Many of the costs and benefits of a transportation project are not financial and may be difficult to quantify. For government-funded projects the balance is further complicated in that the government pays for the project, and others benefit from the development.

As for other types of project, evaluation and decision making consists of determining the value of individual alternatives in order to enable choices to be made. In the case of regional transportation projects, there may be only a single proposal put forward, but there is always another alternative: to do nothing and retain the status quo. This is especially true in the North, where alternative routes are not always possible. However, the choice of transportation method (e.g. all-season road, winter road, rail) may be very important.

An evaluation should identify those affected by the project, whether in a positive or negative manner. Involved in this is a definition of values and a method for

estimating benefits. The evaluation should identify project costs, and who bears those costs. Benefits and beneficiaries must also be identified. A benefit resulting from most transportation projects is a decrease in the cost of transportation; this may benefit local industries and residents. Disbenefits must also be identified, these include pollution and effects of the project upon local lifestyles, e.g. disruption of traplines or hunting grounds. The distributional effects of any transportation project are an important part of evaluation.

Like other government services, the provision of transportation networks cannot be considered to be self-sufficient. The majority of new routes constructed do not provide sufficient revenue to justify their construction on a purely economic basis. However, the non-monetary benefits of transportation are considered to warrant improvement and expansion of transportation services. It is therefore unjust to discredit Northern transportation projects on the basis that they will never pay for themselves. The major difference between major developments in the North and those elsewhere in Canada is the magnitude of the costs, and the low population density. In comparison with some transportation projects undertaken in southern Canada, the investment required for Northern transportation provision is high, and the number of beneficiaries small. This leads to a greater degree of project scrutiny.

Project objectives and rationale.

The objective of this study is to investigate the relationship between transportation infrastructure development and the development of economic mineral resources in the North of Canada. The North is an ideal area in which to study this relationship, due to the

remoteness of many operations and the lack of existing infrastructure.

This study will therefore examine the Northern mining industry, both historically and at the present time, and relate transportation infrastructure developments to the economic development of mineral resources. To do this, a review will first be made of the mining industry in the North. This will be followed by an examination of Northern transportation networks, both existing and proposed. The relationship between transportation development and mineral development will be studied. Finally, an economic evaluation of the issues regarding transportation and mineral development will be made.

The North provides an excellent opportunity to study the economic advantages and disadvantages of a mineral resource-based economy, and the effects of transportation infrastructure on such development. As previously mentioned, the history of non-Native development in the North has been intimately linked with resource industries, including mining. The development of transportation networks has been greatly influenced by the location of mineral developments, and, in turn, has a great effect on the economics of deposits in the modern mining industry.

The idea of a link between transportation and mineral development is not new. Mining companies conducting exploration in remote or inaccessible areas include transportation considerations in project feasibility studies. The subject is addressed in numerous government reports and commissioned studies, such as the Western Arctic Transportation Study, prepared for DIAND by Prolog Planning Inc. in 1985, and the Conference Board of Canada study of

1994, investigating possible economic impacts of investment associated with the Arctic Coast transportation corridor through the Slave Geologic Province in the NWT. In 1987 the Centre for Resource Studies at Queen's University produced a report entitled "*The changing transportation environment of the Canadian mineral industry*" briefly addressing the issue.

In general though, the overall relationship between mining and transportation in the North has been documented in individual cases, without a comprehensive synthesis of the issue. This study will attempt to provide that synthesis.

CHAPTER 2: A HISTORY OF MINING IN THE CANADIAN NORTH

"I wanted the gold, and I sought it;
I scrabbled and mucked like a slave.
Was it famine or scurvy - I fought it;
I hurled my youth into a grave.
I wanted the gold and I got it -
Came out with a fortune last fall, -
Yet somehow life's not what I thought it,
And somehow the gold isn't all."
Robert Service: *The Spell of the Yukon.*

For the majority of Canadians, the image of mining in the North is dominated by visions of the pioneer days, the time of the rugged prospector, the naive cheechako[1] and the gold rush. The poetry of Robert Service[2], excerpted above, and others, romanticizes the North as an area where fortunes can be found, and downplays the realities of Northern life. Mining has played an important role in Northern development since the European 'discovery' of North America. Modern views of the North as a vast resource, mainly untapped and awaiting development, stem from this colonial mentality. A study of mining development is therefore incomplete without an historical context in which to place modern attitudes to the North.

Aboriginal peoples, pre-European contact.

The first peoples in the North were the ancestors of today's Inuit and Dene nations. Aboriginal peoples, for the most part, lived in harmony with the natural resources of

[1] Cheechako is a derogatory term used by experienced miners for young, inexperienced gold-rush stampeders. These people often came to the North totally unprepared for the lifestyle there, lured by the promise of easy gold. Many stayed, and gained experience, many left disheartened, and many died in the North.

[2] Robert Service was a British poet who came to the Yukon late in the Klondike gold rush. He did not dig for gold himself but wrote many collections of poems including "*The Spell of the Yukon and other verses*", "*Ballads of a Cheechako*" and "*Rhymes of a Rolling Stone*" about life in the North.

the area and made little impact on their environment. In the period prior to European 'discovery' and colonization, the Natives used little in the way of minable resources. Copper was collected by the Tutchone in the Whitehorse area (Coates, 1985) and by the Inuit of the Coppermine Gulf area, for use in trading and in the making of hunting and cutting tools. Soapstone was used by the Inuit for carving (as it is today) and many Dene groups made artifacts from copper.

European exploration, the opening up of the North.

The first European exploration of the Arctic was by naval and trading ships attempting to find a Northwest Passage to India and the Far East. In 1576, while on such an expedition, Martin Frobisher collected mineral samples from southeast Baffin Island, convinced that they contained gold. Although these were dismissed as worthless pyrite by some assayers in England, Frobisher managed to convince the British government to finance further voyages into the area. After two trips, in 1577 and 1578, the scheme was abandoned, since no-one was able to produce gold from the barren 'ore'. This was the first European consideration of the Arctic as an area of mineral wealth, a legacy that has shaped Northern development for centuries.

This early period of European Arctic exploration is characterized by little geological knowledge among explorers, leading in many cases to false expectations and 'deposits' similar to the Frobisher case. In the 18th Century, numerous expeditions by the Hudson's Bay Company (HBC) explored the coasts of Hudson Bay and the Arctic Archipelago in search of minerals and Inuit fur traders. Numerous searches for gold and copper in the area north of Churchill were unsuccessful. A report of diamonds in the Little Whale River, on the east shore of Hudson Bay,

resulted in miners being deployed at the Richmond Gulf post in 1750, but again, nothing came of the enterprise. In 1770 the first successful overland expedition to the Coppermine River brought back samples of copper, but no move was made by the HBC to mine the ore (Cooke and Holland, 1978).

Gold Rush days, the era of the stampeder.

During the latter part of the 19th Century there was a migration of prospectors northward from California into Canada. This migration was sporadic, and took the form of a series of gold rushes[1]. This period is characterized by small mining claims, usually worked by one person, or by a group of friends or colleagues. The migration passed through British Columbia, where gold was discovered in the sandbars of the Fraser River in the 1850's and later in the Cariboo Mountains in 1862 (Figure 2.1). Each discovery provoked an influx of gold seekers into the area, the majority of whom moved on when news of a newer strike came.

The first gold strikes in the North came in 1885 in Yukon Territory, where gold was found in bars in the Stewart River. Many prospectors worked the rich Stewart bars during the summer months, producing approximately $25 per day (Webb, 1985; 1885 dollar value). From there, the search moved towards Alaska, and in 1886 coarse gold was found in the Fortymile River (Figure 2.2). This proved to be the first major placer discovery in the Yukon River basin. Miners working year-round could produce $800 per year from a good claim (Webb, 1985). The permafrost proved to be a useful asset, shafts sunk by the miners to reach the rich pay streak had no need of timber supports and linings.

[1] When it became known that gold had been discovered in an area, gold seekers working elsewhere generally raced to the area, in the hope that the claims were richer than those they had been working. In a particularly rich area, other down-on-their-luck hopefuls would join in the gold frenzy. This cycle of hope, promise and disappointment led to many gold rushes in the 19th Century.

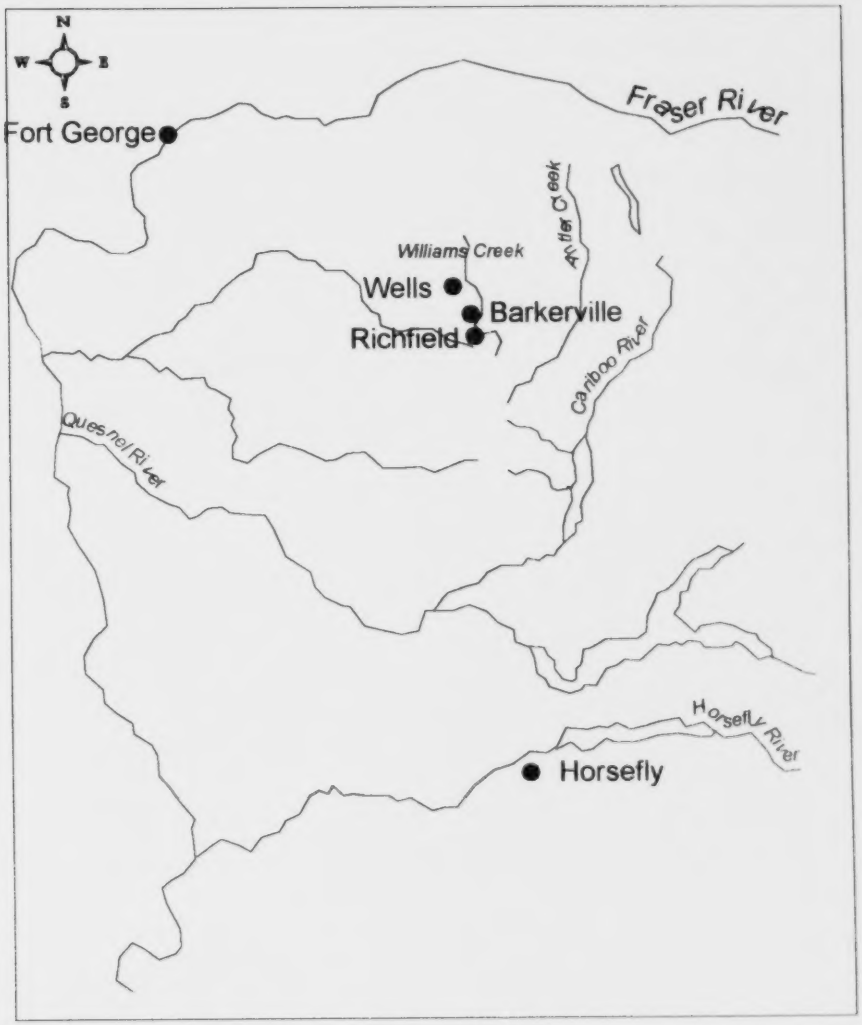

Figure 2.1 Location of the Cariboo Gold Rush, BC: important creeks and towns. Fort George is now Prince George. After Cate, in Place (1970).

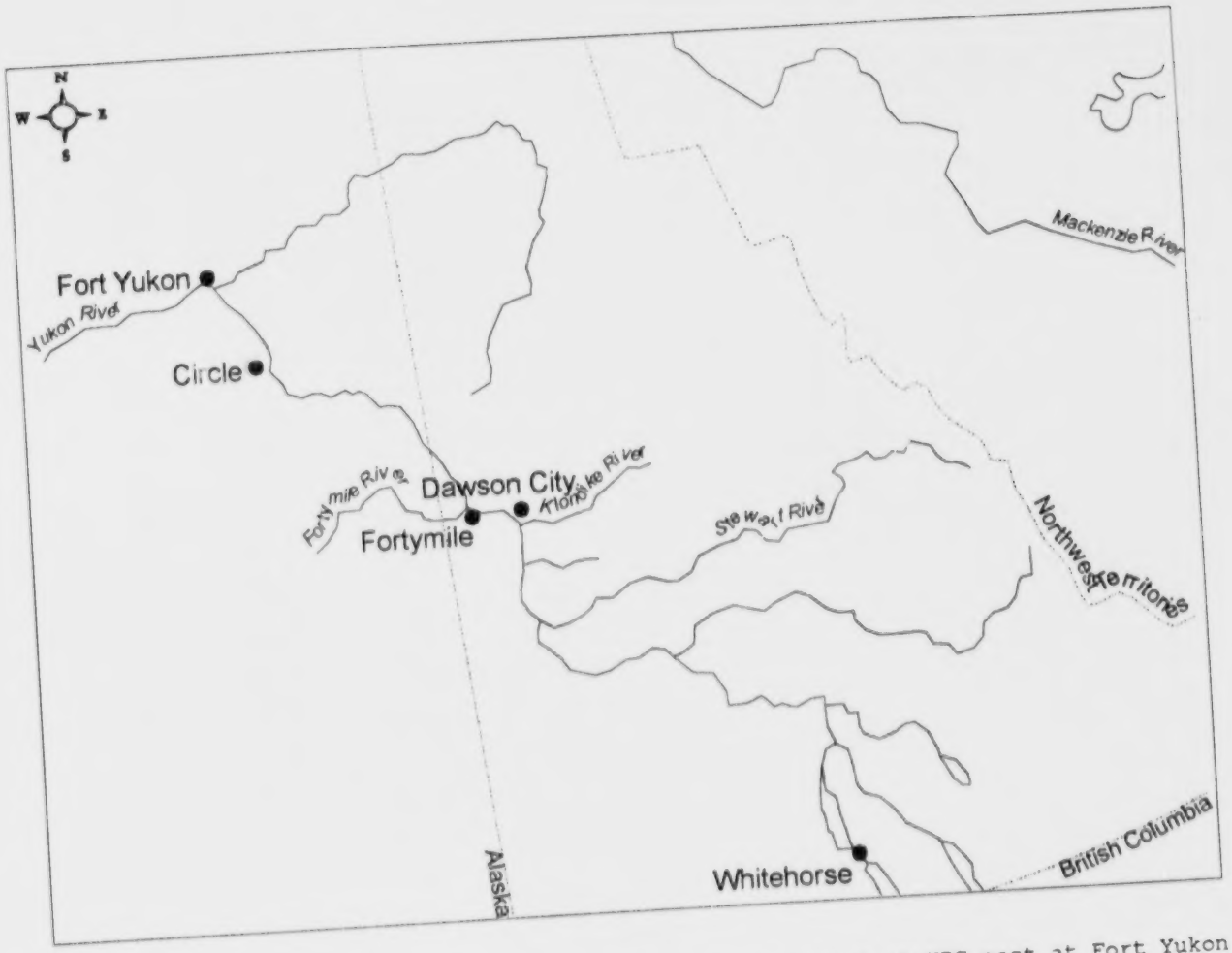

Figure 2.2 The Yukon River goldfields, 1885-1896. Note that the original HBC post at Fort Yukon lay on Alaskan soil. The post was relocated twice before it fell within Canada. After Berton (1987).

Although the rich gold placers lay on the Alaskan side of the Canada-U.S. border, the commercial centre of Fortymile lay within what is now Yukon Territory. This is typical of the frontier mining camps of the 1880's, in which miners had little regard for international boundaries, and officials in the political centres of the south had little knowledge of, or concern for, the Northern frontier. A clear example of this is the siting of the Hudson's Bay Company trading post at Fort Yukon. The original post was located in Alaska, and a new post was constructed upstream. This also proved to be on Alaskan soil, so a third site was required, this time located within Canadian territory.

Exploration continued, and in 1892 gold was discovered on Birch Creek, Alaska. Fortymile was abandoned by many prospectors and their families, and a new settlement was established at Circle City. As prospectors followed the gold discoveries down the Yukon River into Alaska, so did the outfitters, suppliers and other commercial enterprises from Fortymile. This 'boom and bust' cycle was repeated in many frontier mining towns, often within a matter of years. With little interference from the outside world, these short-lived communities developed their own system of order and justice. The miners' meetings provided a forum for grievances to be aired and disputes to be settled within the community.

The discovery of gold on Rabbit (later to be known as Bonanza) Creek on August 17th 1896 changed the face of placer mining in the Yukon River basin forever. The Klondike area had been prospected previously, but had been dismissed as an unprofitable area, with little gold. When the news of George Carmack's rich discovery reached other mining communities along the Yukon River, great numbers of prospectors and miners uprooted themselves and their families and raced for the Klondike. The newly named

Bonanza Creek and its tributary, Eldorado Creek, were rapidly staked by incoming miners as the richness of the area became known. A townsite was established on the flat, marshy ground beside the Yukon River, and later became Dawson City. The Klondike goldfields were richer than anything hitherto discovered in the Yukon basin. *The Chicago Record* in its book *Klondike*[4] reports values from Eldorado Creek up to $153 per pan. Claims of much richer pans were recorded, although some of the 'evidence' is shaky, coming from promotional material provided by outfitting companies in southern Canada and the US, anxious to encourage stampeders to travel north and buy their products. Most of the stampeders in the first staking rush were already in the North at the time of discovery, and by the end of 1896 the majority of the rich ground was taken. News of the gold did not reach the outside until the summer of 1897, when the first steamers carrying wealthy miners arrived in San Francisco and Seattle. This prompted the largest gold rush known in North America, as thousands across the continent, and from around the world, closed up homes and businesses and rushed north to the Klondike.

The size and frenzy of the Klondike gold rush brought many new features to the frontier. Southern officials developed an interest in maintaining order in the community and the international boundaries were more strictly observed. The Canadian government sent officials northward in a display of authority, to maintain sovereignty of the territory over the mostly American gold seekers. The majority of the stampeders never made it to Dawson, or set out for home immediately on arrival, but by 1898 Dawson was the largest Canadian city west of Winnipeg. Due to the

[4] *Klondike: The Chicago Record's book for gold seekers.* Published in 1897 by The Chicago Record. One of many promotional books containing information for would-be stampeders, some of dubious source and largely aimed at profiting from naive, gold-hungry cheechakos.

transient nature of much of the population, the maximum size of the city is unknown since no government census was taken until 1901. A NWMP survey of 1898 reports the population of Dawson as sixteen thousand, this excludes those camped on the creeks or living across the Yukon River in the tent camps of Klondike City (Coates, 1985). The 1901 census recorded a far smaller population of nine thousand, many of the gold seekers having moved on to Alaska and elsewhere by this time (Coates and Morrison, 1988).

Although a great wealth of gold was removed from the Klondike claims, few miners left the area with a fortune. Many spent their gold on liquor, gambling and dance-hall girls, and left as poor as they had come. The gold rush created many misconceptions about life in the North, and changed the nature of the area forever. Environmental issues were not considered in these times, and the effects of mining remain obvious today, even on long deserted claims. Despite the size and fame of the Klondike rush, it had few other lasting effects on the area and its original inhabitants.

As the 19th Century drew to a close, many stampeders deserted Dawson for new gold rush sites, at Atlin, in northern British Columbia, and at Nome and Tanana in Alaska. On June 14th 1898, *The Klondike Nugget*[5] reported on the Nome strike:

> "Undoubtedly the new discoveries will take hundreds of men from Dawson, who, for various excuses, have failed to reach their expectations here."

The placer claims which had made so many prospectors rich became uneconomic for the laborious process of manual gold extraction, and many miners left for the south. New,

[5] A twice-weekly newspaper printed in Dawson City, June 16, 1898 to January 6, 1900, and as *The Daily Klondike Nugget* from January 8, 1900 to July 15, 1903.

high-tech mining equipment was brought in, which led to larger scale operations. Individual claims were consolidated into large stretches worked by companies operating dredges. Mining became more of an industry as gold grades decreased and lower value claims were worked. The furor of 1896-1900 was replaced by more systematic, organized production, controlled by a few interests, dominantly the Yukon Gold Company. Production peaked in 1902-1903 when $12 million in gold left Yukon. The dredges continued to operate until the 1960's. A minor revival of the goldfields occurred in 1973, when the price of gold was floated on the open market, but the boom was over by 1900, and never returned.

Early 20th Century mining in the North, post gold rush.

Gold fever from the Klondike rush permeated much of the North, leading to increased interest in prospecting in both Yukon and the Northwest Territories. Prospectors in Yukon turned away from Dawson, where the claims were rapidly being consolidated and commercially developed, to other areas, many of which had been initially discovered before the Klondike strike. Livingstone Creek, in the Lake Laberge area, and creeks feeding into the west side of Kluane Lake were developed on small scale by prospectors, in the search for a new Bonanza.

Copper, coal and silver-lead deposits were discovered and developed in the Whitehorse area from 1905-1912 (Webb, 1985). Copper production ceased due to high transportation costs, but an increase in the price of the copper ore during the First World War changed the economics, and mining returned. For a while the mine had difficulty maintaining sufficient workforce to meet production requirements, due to the war. Silver deposits in the Tagish area provided short

lived mining opportunities. In 1906, silver-lead deposits were discovered near Mayo and by 1914 mines were operational, transporting the ore by barge and the White Pass and Yukon Railway (Coates, 1985).

The area surrounding Great Slave Lake was initially prospected for gold in the late 19th and early 20th Century. The federal government, eager to encourage investment and to remove Native title to the area, hastily drafted and pushed through the poorly worded Treaty 8 in 1899. Although this agreement covered a vast area of potential mineral wealth (Figure 2.3), its signatories came from only part of the region, due to a greater government concern for economic development than for protection of Native interests. Treaty 11, signed in 1921, has similar aims.

Northern mining development between the wars.

The Yukon mining industry suffered another collapse at the end of World War I. Prices dropped, and copper mining in the Whitehorse district ceased entirely. New vein discoveries and a high silver price kept the Mayo-Keno district mines prosperous, but many smaller companies were bought out by large operations, such as the Treadwell Yukon Company, which built the first mill in the area in 1924 (Coates, 1985). Silver became the main export commodity from the Yukon. In the goldfields, consolidation of small operations continued; in 1929 the Yukon Consolidated Gold Corporation was formed, representing the bulk of gold mining activity. A jump in gold prices during the depression caused an increase in production during the 1930's, but this dropped again during the Second World War.

During the 1920's many companies began working in the area surrounding Great Slave Lake. A minor rush to the Yellowknife area occurred in 1935 after the discovery of

Figure 2.3 The area in the North covered by Treaties 8 and 11.

gold by Norman Jennejohn of the Geological Survey of Canada. The Consolidated Mining and Smelting Company of Canada (Cominco) began to produce gold in 1938, by which time most activity was concentrated around Yellowknife (Dickerson, 1992). Another minor staking rush occurred in 1938 in the Indin Lake area.

In 1931 radium-bearing pitchblende was discovered at Port Radium on Great Bear Lake (Figure 2.4). Eldorado Gold Mines developed and operated a mine until 1940, when the government expropriated the deposit, anxious to protect a supply of uranium to the military. From 1942 to 1960 the mine was operated by Eldorado Nuclear, a Crown Corporation. Total production from the area included 6808 tonnes uranium, 46 930 kg silver, 226 800 kg cobalt, 127 tonnes nickel, 99.8 tonnes lead, 1 292 tonnes copper and 450 grams radium. The Eldorado Mine had a direct effect on transportation development. The mine was originally supplied by aircraft and barge, the barge operation became the Northern Transportation Company Limited (GNWT EMPR, Mineral Industry Report, 1992).

Post-war mining and economics in the North.

The increase in mineral prices in the period immediately following the Second World War brought hope of economic reform for many Northern residents and officials. This period marked an increase in federal government interest in the North, and the mining industry provided a potential economic growth area. Government subsidies to the mining industry at this time were intended to create interest in Northern exploration and to smooth out the 'boom and bust' cycles so prevalent in the mining economy. Examples of these include the Emergency Gold Mining Assistance Act in 1947 and the Northern Mineral Exploration

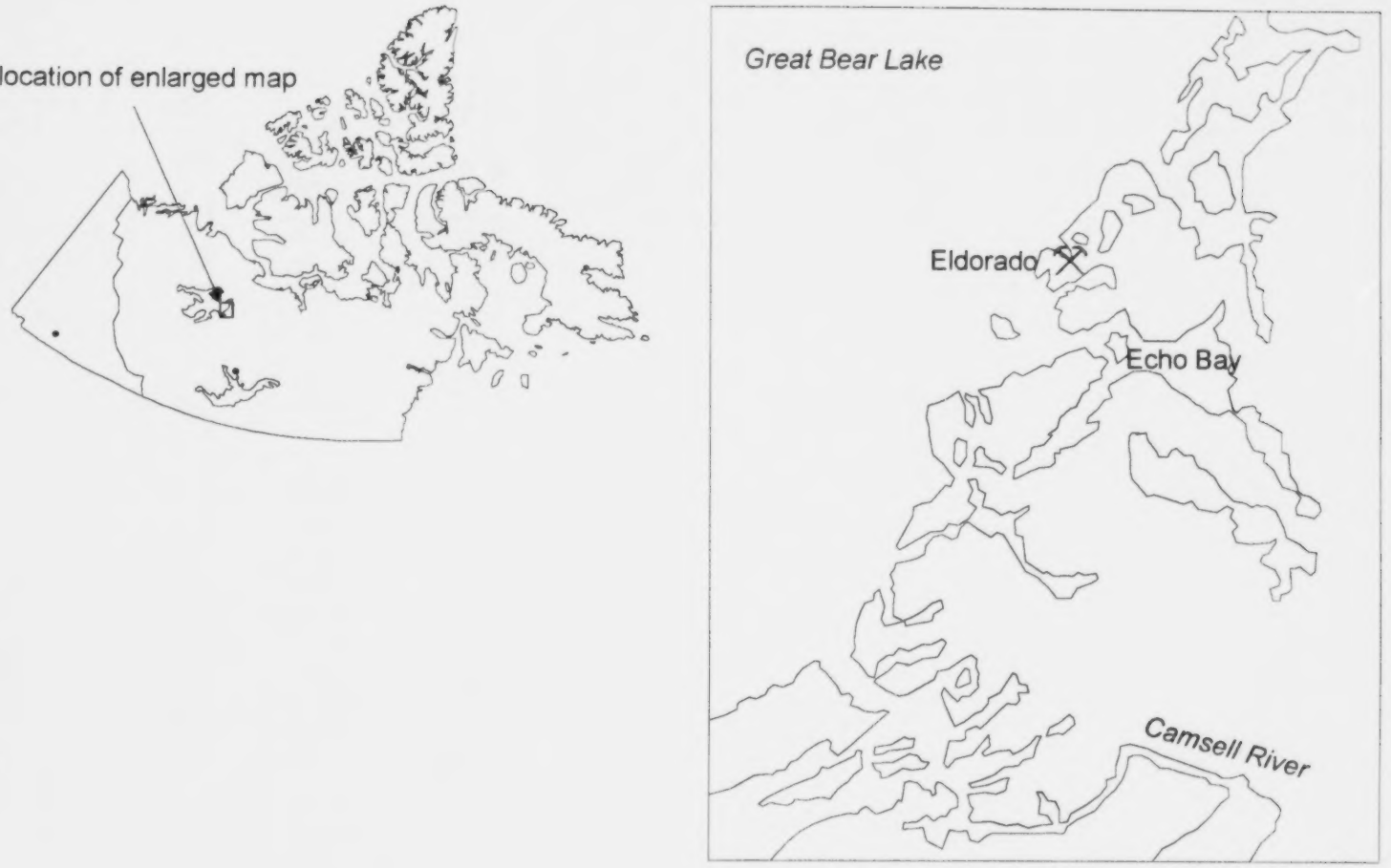

Figure 2.4 The Port Radium area, Great Bear Lake, NWT. After Watt (1980).

Assistance Program in the 1960's. The combination of extensive subsidies, tax concessions, and few environmental restrictions led to a short period of unhindered development.

Interest in many pre-war mines was revived, including Port Radium, which operated until 1982. New discoveries were developed with government assistance. Cominco developed the Pine Point mine after the federal government committed $86 million in public money in 1961 to the building of the Great Slave Railway, to provide ore transportation. Despite this, little attempt was made to connect the mine with local communities. A road connecting the minesite to the local Dene community of Fort Resolution, 42 miles (74 km) away, was not completed until the mid-1970's, when Cominco began recruiting Native employees. The workforce at the mine was mainly transient, with few Native employees. The mine remained open until 1987, with a temporary closure in 1983.

A second gold mine was discovered in the Yellowknife area in 1944. This was developed into the Giant Mine, which poured its first gold brick in 1944, and, like the Con Mine, is still producing gold today. Many other gold mines opened in the NWT in this period, including the Tundra, Salmita, Discovery, Cullaton Lake and Colomac Mines. Some of these mines have operated intermittently up until the present day. Total gold production from the NWT since 1928 is 450 tonnes. Gold was the leading export from the NWT in the period 1939 to 1965 (GNWT EMPR, Mineral Industry Report, 1992).

The Yukon hard-rock mining industry immediately after the war was dependent on United Keno Hill Mines, which was formed by a reorganization of Keno Hill Mining Company after a buyout of Treadwell Yukon Company. UKHM experienced many initial difficulties including finding and maintaining a trained workforce and problems with mining equipment and

supplies, but the returns from the Galena Hill property by the mid-1950's justified their efforts. In 1956 the company showed a net profit of $2 million from lead, silver and gold production. The success of United Keno Hill increased mining interest in Yukon Territory, and in 1952 total Yukon mineral production topped $11 million (Coates & Morrison, 1988). After an initial post-war rush, the area saw a decline in the number of individual prospectors, but the major companies in the area continued exploration. The Yukon Consolidated Gold Corporation continued placer mining in the Klondike region, but by the late 1950's this became uneconomical, even with the aid of the Emergency Gold Mining Assistance Act. Mining finally ceased in 1966. This was partially due to the price of gold being fixed at $35 an ounce until 1973. After this time, when the price of gold skyrocketed temporarily to $800 an ounce, many small operators made profits in the Klondike.

The 1960's represented more of a boom time for the Yukon mineral industry, and a resultant expansion of the territorial economy. Many of the mines which opened in this period were short lived, but provided rich returns during their operation. The Clinton Creek asbestos mine (Figure 2.5) opened in 1965 is a typical case. The planned life of the mine was 20 years, but increased concerns over the health hazards of asbestos, and the high cost of ore transportation led to final closure in 1975. The Clinton Creek townsite, which had been constructed by the operating company Cassiar Asbestos, was dismantled, the buildings were sold, and the workforce moved on to other mining areas.

In 1966 the lead-zinc deposits at Faro, near Ross River, were discovered (Figure 2.5). Lead and zinc had been known about in the area since 1953. The Faro mine, then owned by Cypress-Anvil Mines, began operation in 1969. A combined trucking and rail transport system was organized

Figure 2.5 Post-war mining in Yukon Territory.

with the White Pass and Yukon Railway, to carry the ore to Skagway, the nearest shipping port. Despite generous government assistance for the construction of a townsite, employees were mainly transient workers, with very few Natives.

The 1970's and 1980's have seen changes in the mineral industry of the North. In the NWT, zinc production has overtaken gold production to become the leading mineral export. Zinc production came initially from the Pine Point Mine, and was increased with the opening of the two High Arctic base metal mines: Nanisivik Mine, on northern Baffin Island, which began production in 1976, and Polaris Mine, on Little Cornwallis Island, which opened in 1982. These two mines are still producing, and are discussed further in Chapter 3. Mines in the High Arctic Islands present unique transportation problems, due to the island locations and the short shipping season. At present the two mines are serviced during the summer by the icebreaking vessel *Arctic*, owned and operated by Canarctic Shipping Ltd.

The Lupin Mine, situated in the Barrens on Contwoyto Lake, began producing gold in 1982. The mine is supplied during the winter by a winter ice road from Yellowknife. It is still in operation today, and has produced over one million troy ounces of gold to date.

Recently operating mines in Yukon Territory are shown in Figure 2.5. Nickel was discovered at Quill Creek, near Burwash Landing, and was mined from May 1972 to July 1973, producing approximately 40,000 tons of concentrate before the Hudson Bay Company ceased operation due to insufficient reserves. Tungsten was discovered at MacMillan Pass on the NWT/Yukon border. Development began, but the mine was never opened. At Howard's Pass, further to the south, Canada Tungsten operated a mine for many years before suspension of

operations in 1986. The Ketza River Gold Mine, located near Ross River in the Pelly Mountains, operated from July 1988 to November 1990. The mine produced gold from sulphide and oxide ore. In 1991 the Sa Dena Hes Mine opened near Watson Lake, producing 1500 tonnes of lead-zinc ore per day.

Summary.

It can be seen that mining has always been a major element of life in the North and remains an active part of modern industry. In 1993, total metal mineral production of the North was valued at $500 million (Canadian Mines Handbook, 1994-95). The mining industry of today has evolved a long way from its early beginnings to become a high-tech modern producer with responsibilities beyond simple extraction of metals from the earth.

CHAPTER 3: THE MODERN NORTHERN MINING INDUSTRY

Introduction.

The previous chapter presented a summary of mining history in the North, from the beginnings of European exploration to modern times. This chapter continues that theme, considering the present day Northern mining industry and projects currently in advanced stages of exploration. A survey of Canadian mining companies, many active in the North, was conducted during the summer of 1994, in order to gain insight into industry opinions of the North as a place for mineral exploration and development. A discussion and interpretation of the survey results is given.

Mining legislation and control has a major effect on the perception of an area by mining companies and investors. A brief review is made of the major legislation which affects the mining industry in the North, including the various Economic Development Agreements between the Government of Canada and the Territorial Governments. Environmental legislation is covered in Chapter 5, and is therefore not included in this discussion, but a brief introduction to environmental issues is presented.

Current mining operations and development prospects.

Mines currently operating in the Canadian North involve precious and base metals. These include:

- Giant Mine — *Au*
- Miramar Con Mine — *Au-Ag*
- Colomac Mine — *Au*
- Iron Ore Company of Canada — *Fe*
- Lupin Mine — *Au*
- Nanisivik Mine — *Ag-Pb-Zn*
- Polaris Mine — *Zn-Pb*
- Teck Mining Group — *placer Au*

Table 3.1 lists details of each operation. These mines are located in a variety of geographic areas, and are shown in Figure 3.1. Each has a different approach to the unique transportation issues affecting mining in the North. In addition to the mines listed above, there are other smaller operations, such as individual placer operations in the Klondike region.

There are also a number of projects in advanced development stages in both the NWT and Yukon. These include the Izok Lake Joint Venture base metal (Zn-Cu-Pb) project and two diamond projects in the Slave Geologic Province. Further development of these properties is intimately tied to transportation development. The Izok Lake project was put on hold in February 1994, and remains so at the time of writing. The proposed development of an Arctic Coast transportation corridor, running from Yellowknife to the Arctic Ocean at Coronation Gulf, is based on the economic development of one or more mines in the Slave Geologic Province. This will be discussed further in Chapter 4, and is shown in Figure 4.8.

Other advanced development projects in the North at this time include:

- Brewery Creek Project, YT — *Au*
- Carmacks Copper Project, YT — *Cu*
- Casino Project, YT — *Cu-Au-Mo*
- Prairie Creek Project, NWT — *Au-Pb-Zn*
- Minto Project, YT — *Cu*

These are shown in further detail in Table 3.2. Locations are given on Figure 3.2. Other exploration projects underway include Au properties in the Slave Geologic Province, close to Indin Lake, where the Colomac Mine is located, and in the Keewatin District, NWT. Two major diamond exploration projects in the Slave Province are the

Table 3.1 Mining operations in the Canadian North.

Name of Operation and Location	Owner/Operator	Commodity	Annual Production (1993)	Production Commenced	Identified Reserves	Expected Mine Life
Giant Mine W side of Yellowknife Bay	Royal Oak Mines Inc.	Au	92,948 oz Au	1948	2,617,000 tonnes @ 0.321 oz/t Au. (Dec 1993)	9 years
Miramar Con Mine Yellowknife	Miramar Mining Corporation/ Miramar Con Mine Ltd.	Au Ag	120,000 oz Au 30,000 oz Ag	1938	3,698,755 tonnes @ 0.31 oz/t Au. (Jan 1994)	8 years
Ptarmigan Mine, Tom Mine 12 miles NE of Yellowknife	Treminco Resources Ltd.	Au	7,300 oz Au (to Jul 31, 1993)	1989	55,000 tons @ 0.273 oz/t Au.	*
Colomac Mine 137 miles N of Yellowknife, 64°21'N,115°05'W	Royal Oak Mines Inc.	Au	*	1990	*	*
Iron Ore Company of Canada Labrador City 53°04'N,66°57'W	Iron Ore Company of Canada	Fe	11,500,000 tonnes Fe concentrate and pellets	1962	*	25 years

(continued)

Table 3.1 Mining operations in the Canadian North (continued).

Name of Operation and Location	Owner/Operator	Commodity	Annual Production (1993)	Production Commenced	Identified Reserves	Expected Mine Life
Lupin Mine Contwoyto Lake 65°46'N,111°14'W	Echo Bay Mines Ltd.	Au	217,504 oz Au	1982	3,269,000 tons @ 0.28 oz/t Au. (Dec 1993)	4 years[1]
Nanisivik Mine Strathcona Sound, Baffin Island 73°03'N,84°25'W	Conwest Exploration Company Ltd./ Nanisivik Mines Ltd.	Zn Pb Ag	53,200 tonnes Zn concentrate 300 tonnes Pb concentrate 16,800 kg Ag	1976	2,321,000 tonnes @ 8.5% Zn, 0.2% Pb, 40 g/t Ag. (Dec 1993)	6 years[1]
Polaris Mine Little Cornwallis Island 75°23'N,96°55'W	Cominco Ltd., Pine Point Mines Ltd./ Cominco Ltd.	Zn Pb	151,200 tonnes Zn concentrate 31,700 tonnes Pb concentrate	1982	8,600,000 tonnes @ 13.4% Zn, 3.7% Pb (Dec 1993)	12 years[1]
Klondike Placer Gold Mine 63°45'N,138°40'W	Teck Corporation	Au (placer)	8,309 oz fine Au	[4]	1,000,000 cubic yards @ 0.023 oz/yd[3] Au.	3 years[1]

[1] Based on reserves and 1993 production.

[2] The Colomac Mine was opened in 1990, then closed in 1991 due to low gold prices. The mine was reopened in 1994 by Royal Oak Mines. [3] = data unavailable

[3] Based on zinc reserves and 1993 production.

[4] Placer mining has been occurring intermittently in the Klondike area since the 1896 gold discovery. The Teck operation consists of 112 consolidated claims which are worked seasonally.

Data taken from Canadian Mines Handbook, 1994-95 and company reports.

Figure 3.1 Current mining operations in the Territorial North. *Giant Mine and Miramar Con Mine are located in Yellowknife.

Table 3.2 Advanced development projects in the Canadian North (metals).

Name of Project	Location	Owner/Operator	Commodity	Identified Reserves
Brewery Creek	64°00'N,138°30'W	Loki Gold Corporation	Au	11 million tons @ 0.058 oz/t Au. (Oct 1993)
Carmacks Copper (Williams Creek)	62°21'N,136°41'W	Western Copper Holdings Limited, Thermal Exploration Company/ Western Copper Holdings Limited	Cu (Au)	22 millions tons @ 1.06% Cu, 0.013 oz/t Au. (Mar 1993)
Casino	62°44'N,138°49'W	Pacific Sentinel Gold Corporation	Cu Au Mo	615 million tons @ 0.25% Cu, 0.025% Mo, 0.009 oz/t Au. (preliminary)
Izok Lake Joint Venture	65°37'N,112°47'W	Metall Mining Corporation	Zn Cu Pb (Ag)	16.5 million tonnes @ 2.2% Cu, 11.4% Zn, 1.1% Pb, 60 g/t Ag. (Dec 1993)
Minto	Whitehorse District, Yukon	Minto Explorations Limited	Cu Au Ag	no data available
Prairie Creek	61°35'N,124°50'W	San Andreas Resources Corporation	Pb Zn Ag Cu	4.25 million tons @ 13.01% Pb, 14.65% Zn, 5.9 oz/t Ag. (Dec 1993)

Figure 3.2 Northern advanced development projects.

Dia Met/BHP property at Lac de Gras, and the DHK/Kennecott Tli Kwi Cho property. These are described further in Table 3.3, with the Diavik project, owned by Aber/Kennecott, which has show very good results in 1994. Table 3.4 lists mines and advanced development projects currently suspended for reasons other than resource depletion.

Mining company attitudes to Northern mineral development.

In July 1994, a survey was mailed to the exploration managers of 174 Canadian mining companies, concerning exploration, mining and transportation in the North. To encourage a good response, the survey was brief, but asked important questions about company attitudes towards Northern mining. Forty nine completed responses were received by October 1994. A copy of the text of the questionnaire, with the compiled results from the 49 responses, can be found in Appendix 1.

Of the 49 companies who responded, 76% were currently engaged in exploration activity in the North. 78% of respondents considered the North an attractive mineral exploration target area, with development regulations & legislation being the most mentioned influence (53%). Many companies also added favorable geology and large unexplored areas as another major factor. 76% of respondents felt that Northern Canada is favorable for investment at the current time, however, only 37% consider exploration in the North a priority.

Respondents generally believed that the Territorial Governments do a better job of promoting mining in the North than the Federal Government. Only 18% felt that the Federal Government adequately promotes mining, 51% felt that mining is sufficiently promoted by Territorial Governments. 53% of respondents suggested South America as an area more

Table 3.3 Major diamond exploration projects in the Canadian North.

Name of Project	Owner	State of Exploration
Point Lake/Lac de Gras Slave Province, NWT	Dia Met Minerals Ltd. (29%) BHP Minerals Canada Ltd. (51%)	39 pipes are known on the property area. The Fox pipe contains 0.26 carats per tonne, with an initial average value of $120 US per carat. The Panda pipe contains an average of 90 carats per tonne, with average values estimated at $127 US per carat. Currently in feasibility study and permitting, with construction planned for 1996, and production to start in 1997. The 9000 tonne per day mine plans to exploit 5 pipes, in both surface and underground operations.
Tli Kwi Cho Slave Province, NWT	DHK Resources (35%) Kennecott Canada Inc. (40%) Aber Resources (15%) SouthernEra Resources (10%)	Bulk sampling of the DO-27 pipe on the property returned disappointing results in 1994. Kennecott announced that the sample results did not warrant further bulk sampling of this pipe. Other pipes on the property are being examined, and bulk sampling of the DO-18 pipe is expected in 1995.
Diavik Slave Province, NWT	Aber Resources (40%) Kennecott Canada Inc. (60%)	Still in exploration phase. Fall 1994 drilling results indicate consistent distribution of micro and macrodiamonds in the A-154 pipe. Large diameter drilling is planned for the A-154 and A-21 pipes on the property, and testing of 12 other target pipes in the area.

Table 3.4 Suspended operations and past development properties in the Canadian North.

Name of Project	Owner	Commodity	Identified Reserves	Reason for Suspension
Faro Mine, Central YT		Pb Zn		bankruptcy of Curragh Inc.
Sa Dena Hes Mine, YT		Pb Zn		bankruptcy of Curragh Inc.
Midway Project, southern YT, northern BC.	Regional Resources Ltd./ Nanisivik Mines Ltd.	Pb Zn Ag	1 377 000 tonnes @ 317 g/t Ag, 5.8% Pb, 8.3% Zn	low Ag, Zn prices
Mactung Project, Macmillan Pass, YT/NWT border	Canada Tungsten Inc.	W	6.1 million tonnes @ 1.16% WO3 (u/g) 17.2 million tonnes @ 0.78% WO3 (o/p)	

favorable for mining investment, other areas were: Africa (24%); USA/Central America (18%); Asia (12%); elsewhere in Canada (8%); Australia (4%); and Europe (2%).

On the topic of transportation, 94% of respondents considered the availability of transportation networks to be a major factor in the development of mineral resources. 80% suggested that the transportation network available in the North discourages mineral development. 51% believed that environmental concerns are more restrictive for transportation in the North.

Air, all-weather road, and winter road were the most favored methods of bringing in supplies, both for exploration and for mining operations. Other methods strongly considered for mine supplies were sea, other road and rail. For transport of product to market, an all-weather road was preferred, with sea, winter and other road, air, river and rail all being considered. Only 16% of respondents had conducted feasibility studies on Arctic transportation.

With respect to power generation in the North, the majority of respondents had considered on-site generators fuelled by diesel. Truck transport of diesel was preferred over pipeline or helicopter transport. Hydroelectricity was considered by many, as was power purchased from an external supplier, and natural gas.

The responses to the questionnaire reflect the diverse experiences of those involved in the mineral industry. The current trend is for overseas exploration, especially in South and Central America, with less emphasis on Canadian projects. Many companies are involved in both domestic and overseas exploration concurrently, and do not consider Canadian development to be a priority. To some extent this represents the global outlook which has characterized the

mineral industry for many years. Unlike non-resource industries, mineral exploitation is limited to locations where orebodies exist. A mine cannot simply move to locate itself in a favorable economic regime. However, exploration can be concentrated in areas considered to be favorable for investment.

The exploration process begins with the identification of areas of potential mineralization. This process involves regional geology and geophysics surveys, and is often based upon published information, thus requires no field transport. Once potential areas have been identified, a grassroots exploration is carried out. This requires field transport, in remote areas this is usually provided by bush planes, capable of landing on ice or lake surfaces, or helicopters. These aircraft are utilized through the more detailed exploration stages, for transport of personnel, drilling equipment and supplies. For the transport of large equipment, e.g. for underground exploration, an airstrip may be built, for larger aircraft, or the equipment may be transported on tractor trailer units over winter roads or tundra. An airstrip may also be built to allow fixed-wing aircraft access to a site previously accessible only by helicopter, since helicopter air time is more expensive than for fixed-wing aircraft. Where the target is located close to an existing road, access from that road may be constructed, if this is less costly than air transport. An access road used in exploration may be upgraded and used during mining operations. Feasibility analysis of the deposit will identify transportation methods to be used for construction and operation of the mine.

The mining industry is not homogeneous, and as such has different requirements depending upon mine size, location, commodity to be extracted etc. This also accounts for differences in questionnaire responses. A precious metal or

diamond mine, for example, may use aircraft for transport of product to market, which is not economically feasible for a base metal mine, where volumes of product are much greater. Mines or development prospects located far from tidewater cannot easily use marine transport, but may make use of winter road systems, e.g. Lupin Mine. Mines located close to the current road network will construct access roads from the property to the network, and will not usually utilize other transportation methods, except for personnel in camp situations, e.g. the Ketza River Mine, Central Yukon. This mine was connected to the Robert Campbell Highway by a 40 km access road, allowing highway travel to Whitehorse (~400 km) but brought people from Whitehorse to Ross River by air, for their scheduled work rotations.

From the questionnaire responses, and from the increase in Northern exploration over the past few years, it seems that many mining companies regard the North as a favorable exploration target. The remoteness of many Northern projects has both positive and negative effects on development decisions. The lack of transportation and infrastructure increases the costs of mineral exploitation, but the North remains a popular target for exploration and development, largely due to its unexplored, favorable geology and low population density.

Mining legislation and control.

Much of the legislation relating to the development of mineral resources in the Territorial North is controlled by the Federal Government. Unlike the ten Canadian Provinces, the two Territories do not have legislative control over mineral rights. In some cases, control of mineral rights and development has been included as part of Aboriginal land

claims, but over most of the Territories mineral rights are Crown property.

The laws governing Yukon mining are the Yukon Quartz Mining Act and the Yukon Placer Mining Act. These laws date from the early 20th Century (post gold rush) and are being reviewed and updated. In the NWT, regulation of Crown mineral rights is according to the Territorial Lands Act. More detailed mining practices are governed by the Canada Mining Regulations. A Northwest Territories Mining Act is currently being proposed. In addition, the Canada Mining Regulations are being updated, especially in the area of staking rules, to facilitate modern exploration methods. The original regulations were based on small-scale, grassroots prospecting done on foot, modern methods include the use of air transport, and cover larger areas.

The issue of access to mineral-bearing lands is addressed in the 1986 Northern Mineral Policy, produced by Indian and Northern Affairs Canada. At the time of publication, 4.6% of land in the NWT and 16.5% of land in Yukon was withdrawn from staking. Uses of this land include parks and reserves, conservation, Aboriginal land claims settlements and pending settlements, and non-mining industries. Land removed from staking cannot be exploited by the mineral industry. Uncertainty in political environments with respect to this 'sterilized land' has a negative impact on exploration, discouraging company activity. The Northern Mineral Policy recognizes this problem, and commits the Federal Government to rationalizing and confirming the status of Territorial lands.

Development policies and government involvement.

Both Territorial Governments currently recognize the value of mineral development to the Territorial economy.

Current policies are aimed at encouraging mining exploration and development.

The NWT does not have an industrial policy relating to the minerals industry currently in place, although the Government of the Northwest Territories (GNWT) is working towards a mineral policy for the NWT, specific to the minerals industry.

Yukon Economic Development has recently been developing an Industrial Support Policy. The aims of this policy are to encourage diversified private sector investment in Yukon. This will be done by Government support and investment in transportation and infrastructure, training and education, assistance to Yukon First Nations, and the administration of environmental protection regulations to the benefit of all Yukoners. The policy also includes an Industrial Electricity Policy, which upgrades and replaces the Energy Infrastructure Loans for Resource Development Programs, introduced in 1993.

The NWT does not have any major programs in place providing financial incentives for exploration and development of mineral prospects. In Yukon there is the Yukon Mining Incentives Program (YMIP), which gives financial assistance to individuals and companies for prospecting, exploration and development. The program allows prospectors and developers to apply for funding for grassroots exploration and target evaluation. Three modules exist in the YMIP: grassroots prospecting, grassroots grubstake and target evaluation. The grassroots prospecting grant covers 100% of approved basic operating expenses up to $10,000 per year, for searching for new mineral occurrences in Yukon. The grassroots grubstake grant covers 75% of approved expenses for companies providing prospectors with a grubstake (basic operating expenses as above) up to a maximum of $10,000 per person per year. The target

evaluation grant is for individuals, partnerships or junior companies to appraise an unevaluated occurrence, and prepare it for option or sale. 50% of approved expenses may be claimed, up to a maximum of $20,000 per year. In 1993 28 grants were allocated in the grassroots programs, and 28 in the target evaluation program. Approximately 60% of these were allocated to placer gold projects (Yukon Economic Development, Yukon Exploration & Geology, 1993).

Both Territories have recently entered into development agreements with the Federal Government. In NWT, the Mineral Development Agreement has been operating since 1991. The agreement is worth $8.2 million over the period 1991-1996 and has four parts:

- Geoscience Initiative $7.5 million
  To assist and encourage mineral exploration by adding to a systematic modern information base on the relation between mineral deposits and geology in sufficient detail to identify areas most favorable for economic mineralization.

- Technology Initiative $200,000
  To assist NWT businesses in the development of innovative technologies, to improve mining and processing operations, and to adapt the operations to Northern conditions.

- Information Initiative $200,000
  To inform and educate the public about the role of the mineral industry in the NWT economy, and opportunities for the participation by NWT businesses and residents, with a view to encouraging interested residents to take advantage of income and employment opportunities available in the industry.

- Prospectors Initiative $300,000
  To encourage NWT residents to acquire training and become experienced prospectors.

These four initiatives are administered by a management committee with members from Energy, Mines and Petroleum Resources, GNWT; NWT Geology Division, DIAND; Mineral Policy Sector, Natural Resources Canada; and Economic Development and Tourism, GNWT. The NWT Chamber of Mines is represented by an advisory position.

The Prospectors Initiative supported eight NWT prospectors in the summer of 1992, and sixteen in the summer of 1993 (GNWT EMPR, Mineral Industry Reports 1992,1993).

The Canada/Yukon Economic Development Agreement (EDA) includes a Mineral Development Agreement (MDA). 70% of funding for the EDA comes from the Federal Government, and 30% from the Government of Yukon. The MDA agreement provides funding under one of three elements:

- Geoscience Element
  To promote an active and successful hardrock and placer exploration industry by accelerating the development of a comprehensive, modern geoscience information base.

- Technology Element
  To increase the economic and environmental efficiency of Yukon placer and hardrock mining operations by encouraging innovative exploration, mining and processing technology, as well as projects aimed at reducing or mitigating environmental impacts.

- Information Element
  To communicate information about the mining industry to Yukon residents and to encourage business to take advantage of economic opportunities in the industry.

The MDA is managed by a committee consisting of representatives from Indian and Northern Affairs Canada; Mining Sector, Natural Resources Canada; Government of Yukon; the Council for Yukon Indians; and the Yukon Chamber of Mines.

The effects of mining on the environment.

From the industrial revolution to the 1960's, economic and industrial development occurred without much concern for the natural environment. With an increase in global industry, many people became aware of the effects of this industrial development on the environment of planet Earth. As awareness of these effects has increased, many industries have changed their operating practices, governments have

developed regulations, and improvements have been made. However, many scars and disasters remain from past times, these still occur today in areas where the financial climate is less amenable to the added costs of environmental awareness, or where regulations have been stretched or broken.

Despite the fact that mining companies today have some of the best environmental programs which exist, the legacy of past mining has convinced some members of the public that all mining is bad, and should be discouraged. The public demand for mineral products and fuels remains high, creating an environmental paradox which is frequently not addressed by extremists. Mineral exploitation, especially surface mining, does disturb the land, mining companies are making every effort to ensure that this disturbance is minimized; mining and processing wastes and effluents are carefully contained; and local ecosystems protected. The modern mineral industry works within government legislation and regulations to minimize the environmental impacts of mining.

Summary.

Although the mineral industry in the North today is not as active as it has been in the past, there is still significant mining activity. The survey results indicate that Canadian mining companies are interested in the North as an area for exploration and development of mineral resources. Interest in other areas of the world reflect the more global nature of the modern mining industry, but the North remains a promising area in the eyes of many. As with any other industry, the bottom line is economics. In the North, a major part of the economics of a mine is the cost of constructing and operating the required transportation infrastructure. The lowest cost producer (overall costs)

will be favored. Government policy and mining control must be aimed at creating a viable, safe and responsible industry into the next century. This will require the cooperation of the entire mineral industry, and will entail new approaches to the industry, transportation and the environment. Transportation and environmental issues will be further discussed in the following chapters.

CHAPTER 4: TRANSPORTATION IN THE CANADIAN NORTH

Introduction.

The object of a transportation system is to move items from their current position to one in which they have a greater value. This is most obvious in the case of industrial and commercial transport, goods are transported from the site of production to a market area. With respect to the development and operation of a mine, the following transportation requirements exist:

1. transport of supplies, fuel, personnel and samples during exploration stages
2. transport of construction material, equipment, personnel and supplies to the minesite for construction of the project and plant
3. transport of the mineral commodity to smelter or market
4. transport of fuel and supplies to the minesite
5. transport of personnel to and from the minesite
6. transport of materials to and from the minesite at the end of production during decommissioning

Items 1 and 2 apply to the pre-mining development period, items 3, 4 and 5 apply to active production, and item 6 applies to post-production environmental reclamation and salvage of mine equipment. There may be a considerable time delay between the cessation of mining operations and the environmental cleanup, depending upon the nature of the closure. Mines which cease production due to economic difficulties may be placed on care and maintenance (e.g. the Ketza River Gold Mine, Central Yukon) and may not be terminally closed for many years.

The selection of transportation method depends upon availability, commodity to be transported, location of mine and market, economics and the environment. The economics of transportation are linked to locality, geography and current availability. Transportation is a major economic factor in

determining the feasibility of developing a mineral deposit, especially in the North of Canada, where the existing transportation network is limited, and climatic conditions are often severe. This chapter examines the transportation methods currently used by the Northern mining industry and reviews some of the innovative alternatives available.

Transportation in the North of Canada.

Transportation in the North of Canada faces many unique difficulties. However, the methods of transportation used in the North do not differ greatly from methods used elsewhere. The difference lies in the application of these methods to the special conditions in the North and adaptation to local and regional situations.

Conventional transportation methods currently used in the North of Canada are: air (fixed wing and rotary wing aircraft), marine (including icebreakers), river, road and pipeline. Each method has a season of availability, with the exception of air, pipeline and some road transport, which operates year-round. Rail transport has operated historically in parts of the North, but the rail network is not extensive and is not used by the mining industry within the study area at present. Rail transportation is used today by the Iron Ore Company of Canada at its Carol Mine in Labrador. Many of the operating conditions there are equal to those in the study area. The disadvantages of rail transportation are the specific terrain requirements for the rail line and the very high cost of construction (from $1.0 million per kilometre). Canadian Arctic and Subarctic rail routes are shown in Figure 4.1.

Transportation policy and implementation is the responsibility of the territorial governments. There are many differences in the historical development of transport

Figure 4.1 Rail routes in the Canadian Arctic and Subarctic.

networks between the two Northern territories, thus the evolution of transportation in each territory is described individually below.

Transportation in Yukon Territory.

The development of the modern transportation network in Yukon Territory is directly related to mining activity. When the first white people came to the territory, they used the rivers and lakes as their transport routes. During the Klondike Gold Rush, this system developed from small boats and rafts, which were built by individual prospectors to transport themselves to new exploration areas, into a sophisticated sternwheeler fleet, travelling the Yukon River and other large navigable waterways. The only railway in Yukon Territory, the White Pass and Yukon Route, was built to carry people and supplies from the marine port of Skagway to the upstream limit of navigation of the Yukon River, at Whitehorse, a total length of 110.4 miles (177.7 km). Railway construction began in May 1898, and was completed in July 1900. The cost of construction at this time was $10 million (1900 dollars). At the time of construction, the majority of traffic in Yukon was between Dawson City and the "outside", as anywhere beyond the Klondike mining camps became known. Other transport within Yukon relied on river canoe, horse and foot.

Little changed until the Second World War, when the United States, anxious to protect Alaska from a possible Japanese invasion, began talks with Canada about an overland route to Alaska. This project initially consisted of improvements to a series of airstrips between southern Canada and Alaska, passing through British Columbia and Yukon, known as the North West Staging Route. The US military wanted a land connection to Alaska, however, which

became the Alaska Highway (Figure 4.2), running from Dawson Creek, British Columbia, to Fairbanks, Alaska. The rough, gravel 'pioneer' road was built in 8 months during 1942, by members of the US Army Corps of Engineers, through very difficult and unfamiliar territory. This was followed by upgrading by military and civilian teams, thus providing a transportation link to Alaska. The road has been upgraded and rerouted many times since its construction, and now has a paved surface along most of its length. Other major wartime projects were also undertaken in Yukon, including the CANOL pipeline and road. The pipeline was built to bring oil from the Norman Wells oilfield (NWT) to a refinery in Whitehorse and from there to various points in Alaska and the south (Figure 4.2).

The perceived Japanese invasion never materialized, and enthusiasm for the road and infrastructure gradually diminished, but the construction changed the transportation networks in the North forever. During the period of river transportation, transport availability dominated economic development. Only communities or ventures with access to waterways were economic, or possible. With the coming of the road network, industry could be developed away from the major rivers. Transport became a servant to industrial development, rather than the master. The coming of the road allowed the growth of the trucking industry, which meant that goods could be carried to and from Yukon over an all-Canadian route.

The modern road network in Yukon is extensive, with over 4500 km of highways (Figure 4.3). Of these, 3628 km are designated as trunk highways. Surfaces include 265 km of pavement, 1718 km of bituminous surface, 469 km of dust-treated gravel and 2283 km of gravel highway[1]. The

[1] Completed road surfaces according to the 1994-95 Capital Estimates. Government of Yukon.

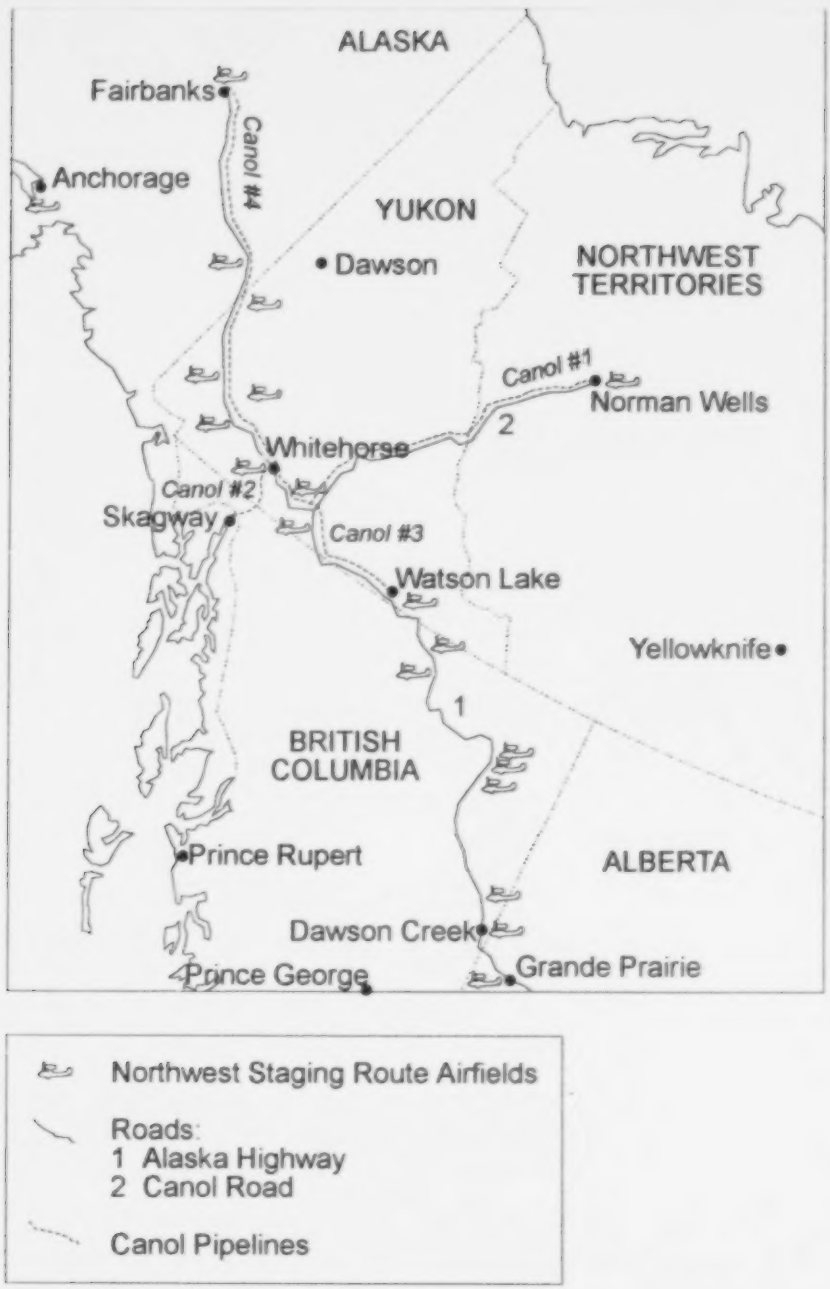

Figure 4.2 U.S./Canada military developments in World War II, including the original Alaska Highway, the CANOL pipeline system and the Northwest Staging Route airfields. After Morrison and Coates (1994).

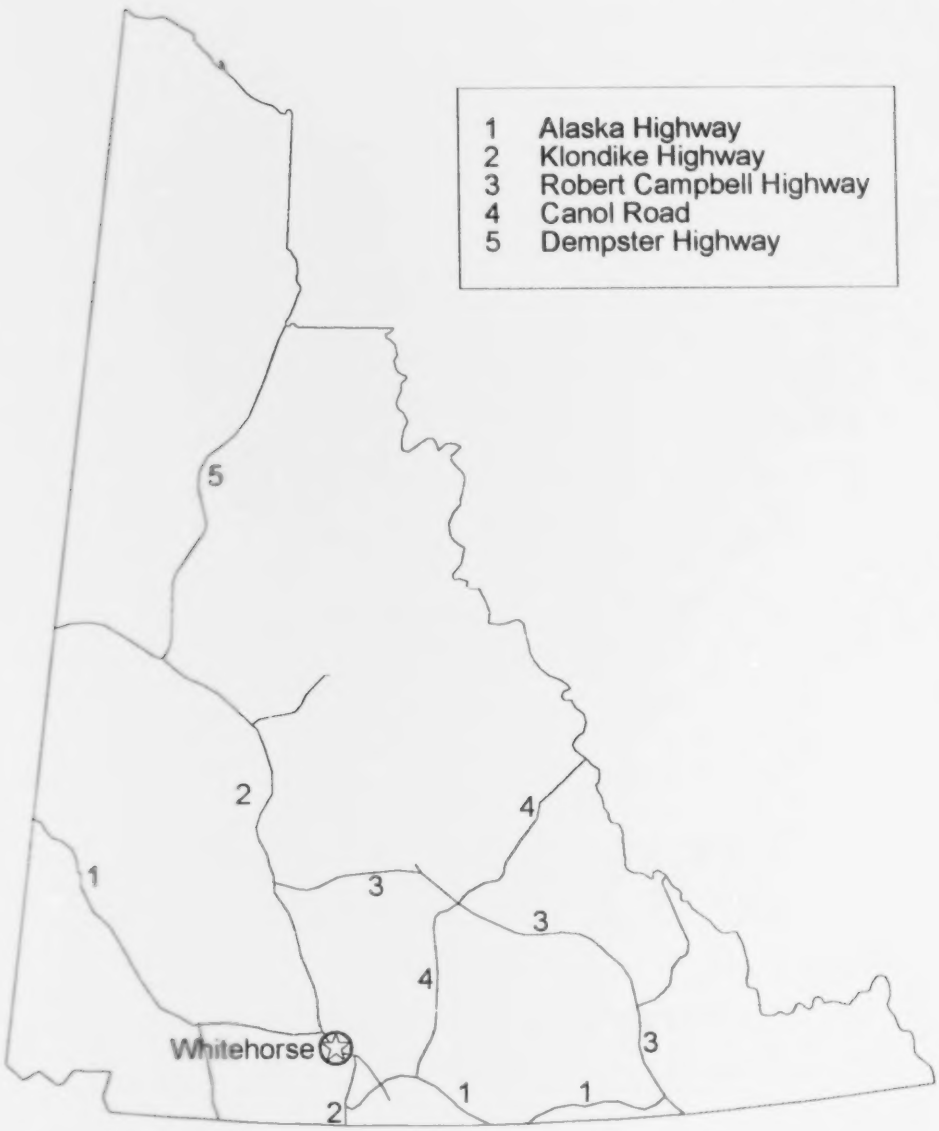

Figure 4.3 The modern Yukon highway network.

network has developed as a response to industry and tourism, with mining as the dominant industry. With the exception of the northern and northeastern section of the territory, there is road access close to most possible new mine sites (e.g. the Brewery Creek project of Loki Gold, located near Dawson City). Development of new mines will require the construction of access roads, but the major routes already exist.

The railway from Whitehorse to Skagway operated until 1983, when it was shut down due to economics, much of its cargo having been transferred to trucking routes. Trucking is the dominant method of freight transport in Yukon today.

Apart from Transport Canada airports at Whitehorse and Watson Lake, there are 10 community airports, with runway lengths of 3740 to 6000' (1140 to 1830 m) and 17 emergency airstrips. These airports are predominantly used for community resupply, and for passenger traffic. Air travel has been used by the mining industry for employee travel, e.g. the Ketza River Mine (1988 to 1990) flew employees between Whitehorse and Ross River at the beginning and end of their work rotation.

Transportation in the Northwest Territories.

Early explorers and prospectors in the Northwest Territories travelled via rivers and lakes, or by way of the Arctic Ocean. In many areas of the NWT, the only changes have been the addition of air service. The coming of air travel was responsible for much of the 'opening up' of the NWT to the white man, especially in the Eastern Arctic. While white explorers travelled extensively on the river systems of the Mackenzie Valley and Western Arctic, before aircraft most exploration and settlement in the Eastern Arctic was confined to coastal sites. The discovery of many

exploitable natural resources came only after aerial exploration. NWT airports are shown in Figure 4.4, and listed in Table 4.1.

Unlike Yukon, the NWT had little accelerated development during the Second World War. The NWT, not being en route to Alaska, attracted little wartime attention from the US. The Norman Wells oilfield was utilized for a short period, during which time the CANOL road and pipeline was constructed, but the project was soon abandoned by the army. The NWT portion of the CANOL road has since fallen into disrepair and remains only as a hiking trail. The US proposed a series of Eastern Arctic airport upgrades, similar to that in British Columbia and Yukon, to form a North East Staging Route, linking through Ontario and Quebec to protect Greenland and the Arctic from invasion. Three possible routes were proposed, but little of the airport upgrading actually took place.

The road network in the Northwest Territories (Figure 4.5) is much less developed than that in Yukon. Road transport between Yellowknife and southern Canada began in the late 1930's, with attempts to lower the cost of transportation of supplies to Yellowknife, which by then was an established mining community on the north shore of Great Slave Lake. The Mackenzie-Yellowknife highway system (Figure 4.5) did not reach Yellowknife until 1961 (Hamilton, 1994). The total area of NWT is much greater than Yukon, but many parts of the territory remain accessible only by air, or by barge or ship during the summer months. The Mackenzie River barge system remains one of the crucial supply lines to Western Arctic communities which are not accessible by road. The Mackenzie Highway follows the river as an all-season road to Pe Tséh Kí (Wrigley) and continues as a winter ice-road to Inuvik. The Territorial Government is working to provide an upgraded and more extensive road

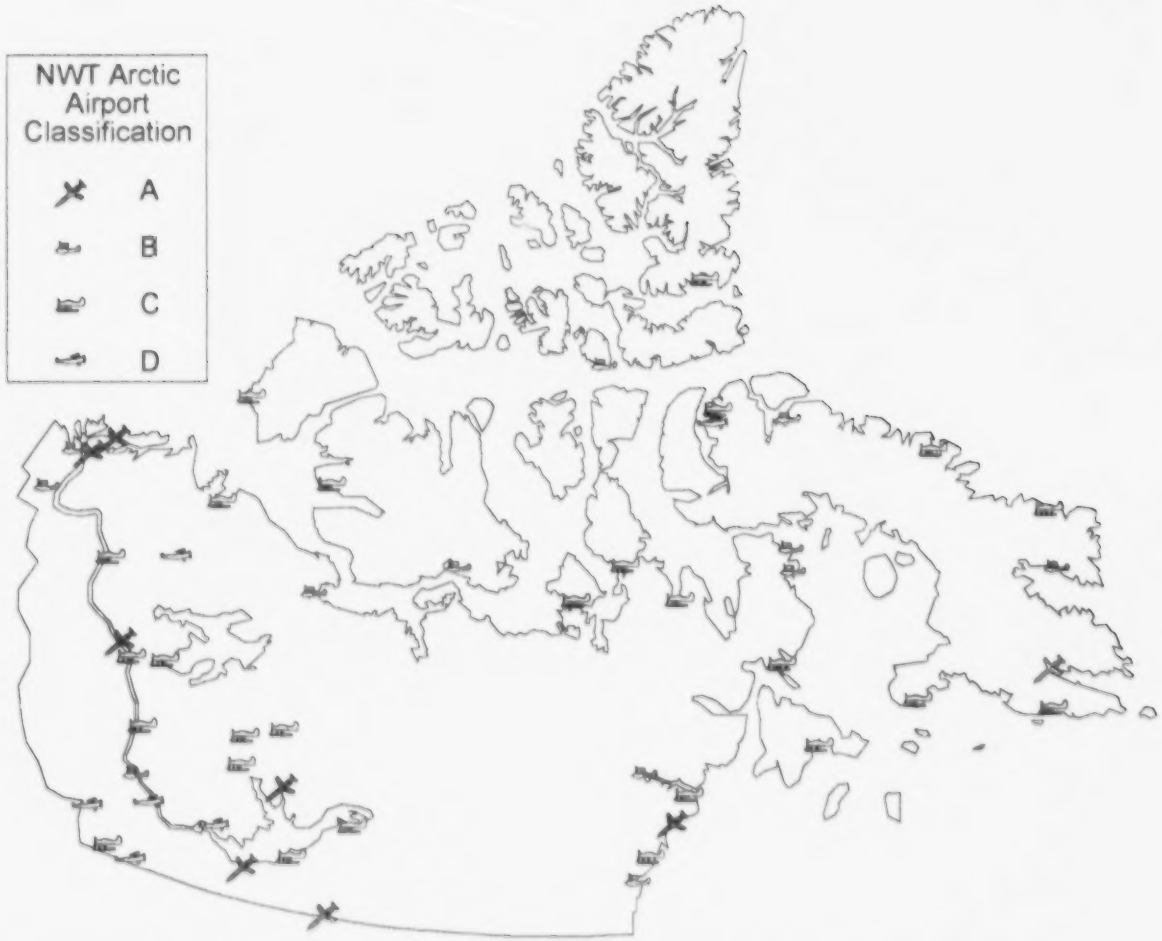

Figure 4.4 NWT Airports. The Arctic 'C' airport at Sanikiluaq is not shown. Arctic airports and classification data are shown in Table 4.1, page 62.

Table 4.1 Arctic Airports in the Northwest Territories.

Community	Owner[1]	Class	Critical Aircraft	Runway Length[2]
Yellowknife	TC	A	B737	2,286
Inuvik	TC	A	B737	1,829
Iqaluit	TC	A	B737	2,743
Norman Wells	TC	A	B737	1,829
Hay River	TC	A	B737	1,849
Tuktoyaktuk	GNWT	A	B737	1,524
Fort Smith	TC	A	B737	1,829
Rankin Inlet	GNWT	A	B737	1,524
Cambridge Bay	TC	B	B737	1,524
Resolute	TC	B	B737	1,981
Fort Simpson	TC	B	Electra	1,829
Aklavik	GNWT	B	Twin Otter	914
Baker Lake	GNWT	B	HS748	1,280
Hall Beach	GNWT	B	B737	1,646
Pangnirtung	GNWT	B	HS748	883
Coppermine	GNWT	B	Electra	1,524
Arviat	GNWT	B	HS748	1,219
Fort McPherson	GNWT	B	Twin Otter	1,067
Pond Inlet	GNWT	B	HS748	1,219
Igloolik	GNWT	B	HS748	1,158
Cape Dorset	GNWT	C	HS748	1,219
Gjoa Haven	GNWT	C	HS748	1,341
Spence Bay	GNWT	C	HS748	1,039
Nanisivik	GNWT	C	B737	1,951
Fort Good Hope	GNWT	C	Twin Otter	914
Fort Norman	GNWT	C	Twin Otter	914
Broughton Island	GNWT	C	HS748	1,359
Clyde River	GNWT	C	HS748	1,067
Coral Harbour	GNWT	C	HS748	1,524
Snowdrift	GNWT	C	Twin Otter	683
Fort Franklin	GNWT	C	Twin Otter	762
Wrigley	GNWT	C	Cheyenne	1,067
Lake Harbour	GNWT	C	Twin Otter	518
Repulse Bay	GNWT	C	HS748	1,036
Pelly Bay	GNWT	C	HS748	1,473
Whale Cove	GNWT	C	HS748	1,200
Sanikiluaq	GNWT	C	HS748	1,158
Fort Resolution	GNWT	C	Cheyenne	1,265
Lac la Martre	GNWT	C	Twin Otter	671
Chesterfield Inlet	GNWT	C	HS748	914
Fort Liard	GNWT	C	Twin Otter	914
Holman	GNWT	C	Electra	1,311
Sachs Harbour	GNWT	C	Twin Otter	1,219
Paulatuk	GNWT	C	Twin Otter	975
Rae Lakes	GNWT	C	Twin Otter	853
Grise Fiord	GNWT	C	Twin Otter	610
Nahanni Butte	GNWT	D	Twin Otter	762
Jean Marie River	GNWT	D	Twin Otter	762
Trout Lake	GNWT	D	Twin Otter	762
Fort Providence	GNWT	D	Twin Otter	914
Colville Lake	GNWT	D	Twin Otter	823

[1] TC: Transport Canada; GNWT: Government of the NWT

[2] in metres

Summarised from the *Northwest Territories Transportation Agenda*, GNWT 1990.

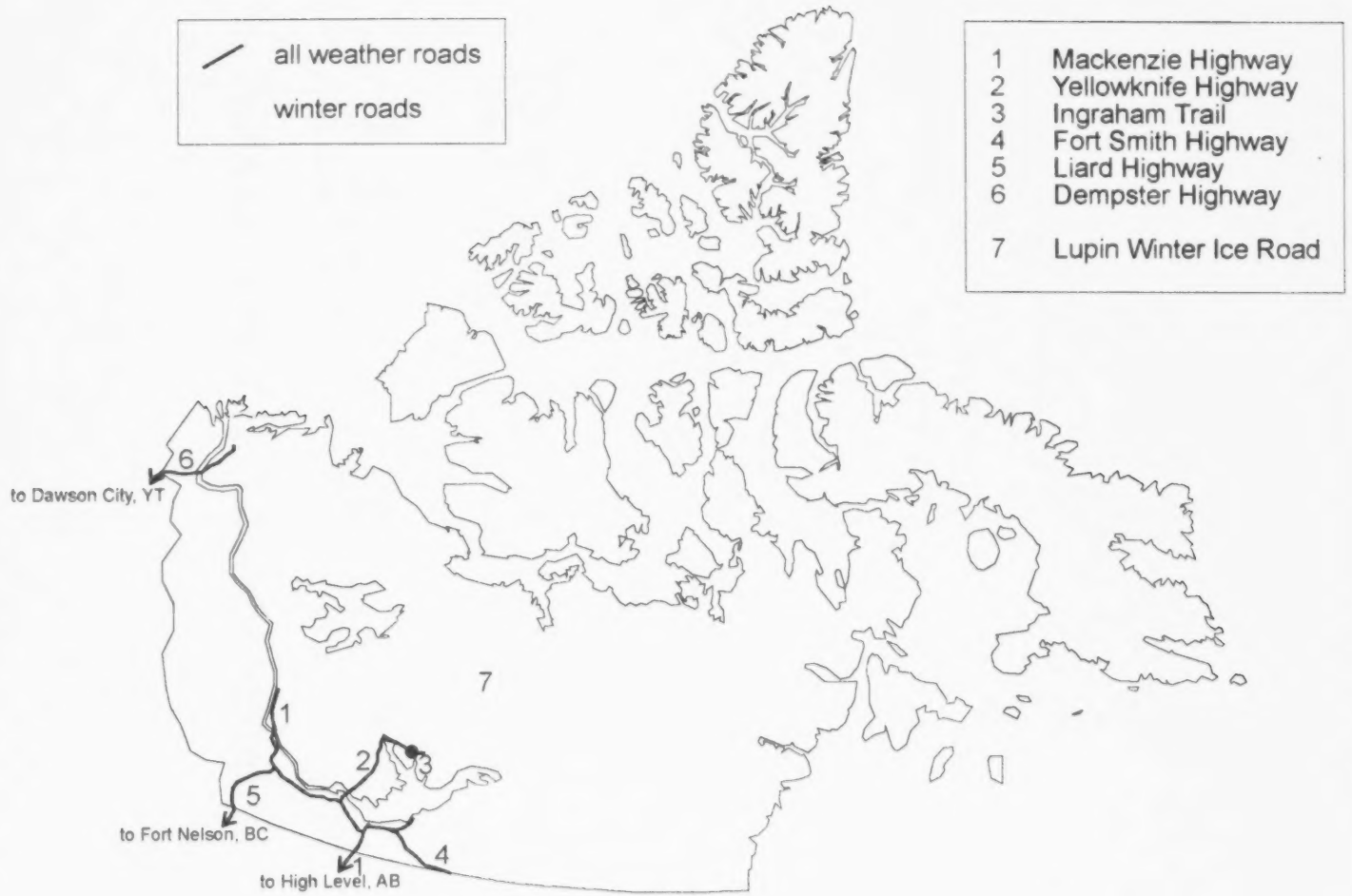

Figure 4.5 The modern NWT highway network.

network, but the cost of new roads is very high (up to $0.9 million per kilometre[2]) particularly in the Canadian Shield where construction conditions are difficult, distances great and construction materials scarce. The current NWT primary highway network includes 2200 km of all-season roads, of which 530 km are paved, 1075 km are gravel treated with calcium chloride to reduce or eliminate dust, and 595 km are untreated gravel (John Bunge, personal communication). There is also 1800 km of winter roads. The road system provides all-season access to 52% of the NWT population and winter access to a further 9% (NWT Transportation Strategy, 1990).

Many communities, especially in the Eastern Arctic, are located in coastal areas and can be more effectively supplied by ship than by road. Mines located on the High Arctic Islands have made effective use of this marine shipping system in their operations. Part of the GNWT transportation budget is allocated to maintenance and operation of marine facilities for coastal communities.

Mining utilization of transportation networks.

As stated previously, many of the transportation developments in both Yukon and NWT occurred as a result of the mining industry. Mining today uses much of the current network, with the exception of the two railways. Modern mines use the all-weather road network (e.g. Yellowknife mines), winter roads (e.g. Lupin), marine shipping (e.g. Polaris, Nanisivik) and air transport. Excepting mines located on the all-season road network, most operations use a combination of transportation methods, each having a different application and season of operation.

[2] Based on a projected cost of $570 million for the 650 km road from Yellowknife to Coronation Gulf. Conference Board of Canada, 1994.

Air transport.

Mining utilization of air transport in the North involves both regular scheduled air services and dedicated chartered flights. Mines operating in remote areas fly their employees to and from the minesite on regular rotations (e.g. Lupin Mine, Nanisivik Mine, Polaris Mine). Gold and other precious metal mines also utilize aircraft for transport of the product to market.

Air transport has the advantage of being fast, it also is somewhat unaffected by geography. As long as there is sufficient space for an airport, air transportation is viable. The disadvantages of air transport include the high cost, and the sensitivity to bad weather. Air transport is most appropriate for low-bulk, high-value or perishable goods, in areas where other transportation modes are impractical, or for transport of personnel.

Marine transport.

The main use of marine transport in the Canadian mineral industry is in exports. However, two base metal mines, Polaris Mine and Nanisivik Mine, situated at tidewater in the High Arctic Islands, rely heavily on the marine mode for transportation of their product to market and for inbound transportation of non-perishable supplies. The product of these two mines is Pb and Zn concentrate, totalling 326,400 tonnes per year (Mining Journal Supplement, 1993). This is transported to smelters in Europe using Type B cargo ships[3], during the short summer shipping season. The season is regulated by the Arctic Shipping Pollution Prevention Regulations on a zonal basis,

[3] As defined under shipping law (Canada Shipping Act and Arctic Waters Pollution Prevention Act). Arctic Class ships are those specifically designed for icebreaking. Type ships are not designed for icebreaking, but for navigating in ice covered waters (Canadian Coast Guard, 1992).

and lasts from August 1 to September 30 at Polaris. Canada Coast Guard Ice Class 4 icebreaking ships accompany these cargo ships through the ice-rich channels of Lancaster Sound and Wellington Channel. The MV Arctic, an Ice Class 4 icebreaking cargo ship, carries ore and supplies at the beginning and end of the shipping season, when sea ice conditions are more restrictive.

Non-perishable and bulky items are transported to these offshore mines by Type B cargo ships. Supplies for the camp at Polaris and the townsite at Nanisivik are shipped from Montreal on the inbound leg of a concentrate cargo trip. Mine and processing plant supplies are obtained in Canada or Europe and are shipped yearly. Equipment requiring off-site service or repair is also transported by ship.

Arctic marine transport requires careful planning and preparation. The shipping season is restricted by law, depending upon the ice class of the vessel and the location of the passage. Ice conditions are monitored in advance, using Atmospheric Environment Service Ice Branch data, and also observed on-ship by a trained ice observer. Environment Canada maintains an Ice Centre in Ottawa which monitors ice conditions and distributes data to local Ice Operations Offices. Observation flight data from Ice Branch reconnaissance aircraft can also be transmitted to suitably equipped ships.

River transport.

The major use of river transport by the mining industry occurred in the late 19th and early 20th Centuries. During this time, transport by barge and sternwheeler represented the only method of getting goods to and from the North. Current large-scale use of river transport is limited to the Mackenzie River and Great Slave Lake, and is not utilized by

the mining industry. This is primarily a feature of mine location, operating mines are either located away from the river network or are close to the road network, which is cheaper and more convenient to use.

Past examples of the use of river transport by the mining industry include the Klondike goldfields in Yukon Territory and the Port Radium mines on Great Bear Lake, NWT.

Pipeline transport.

Pipeline transport is currently used in the North by the oil and gas industries. The first major pipeline built in the Canadian North was the CANOL pipeline, from Norman Wells to Whitehorse. This was constructed by the US Army in 1942-43. Parts of the pipeline had to be rebuilt during construction due to a lack of permafrost engineering knowledge. The CANOL pipeline was abandoned almost as soon as it was built, as the war came to an end.

In 1974 the Arctic Gas consortium proposed the construction of a pipeline down the Mackenzie Valley, to transport gas from the Arctic to southern markets. The Federal Government at the time set up a Royal Commission to examine this proposal, headed by Justice Thomas Berger. Berger's report: *Northern Frontier, Northern Homeland,* published in 1977, recommended that no pipeline be built along the Mackenzie Valley for ten years, and that no pipeline be built across northern Yukon from Prudhoe Bay, Alaska. The report was remarkable for its time with regard to the recognition and respect for aboriginal rights. Berger's findings were not what was expected by industry or government.

The alternative proposal, to build a gas pipeline down the Alaska Highway, was approved by the Federal Government. In 1985 Imperial Oil constructed a pipeline from its Norman

Wells field to Zama, Alberta. However, pipelines have yet to be utilized by the mining industry, in terms of slurry transport etc. One of the major problems with northern pipelines, as for any surface construction, is the presence of permafrost. It is important that flow in the pipeline does not thaw or freeze areas of ground. Thaw of permafrost results in instability of foundation and may have far reaching effects. Freezing of unfrozen ground in the discontinuous permafrost may result in ground movement and buckling of the pipeline. The result is a higher risk of fracture and spillage than in pipelines constructed outside permafrost. Despite the successful operation of pipelines in the North of Canada, and in Alaska, the environmental risks are often considered too great, and new pipelines are not favored.

Road transport.

Road transport in the North is not necessarily limited to permanent, all-season roads[4]. Many areas are accessible by road only in the winter, when seasonal ice and snow roads are built. The construction and maintenance of a winter road is considerably cheaper than that of an all-season road[5]. Ice roads are used primarily in the Northwest Territories, where the all-season road network is less extensive than in Yukon Territory. The Lupin Mine constructs an ice road each year (Figure 4.5, Plate 4.1) to bring in a year's supply of fuel and bulk goods. The ice road is used as a seasonal supply line for the type of goods

[4] Also known as all-weather roads.

[5] Considering a proposed road from the Izok Lake base metal deposit in the Slave Geologic Province to a deep-water port in Coronation Gulf, construction costs for a winter road are estimated at $35 million, with annual maintenance of $2 million. For an all-season road, construction costs are estimated at $200 million, with annual maintenance of $4 million. The all-season road construction would take three years, during which time the winter road would be required (Conference Board of Canada, 1994).

Plate 4.1 The Lupin winter ice road, constructed each year by Echo Bay Mines Limited. Photo taken by Ian R. Muirhead.

transported by ship to Polaris and Nanisivik Mines. The only other access to the Lupin Mine is by air, thus it is most cost effective for bulky and heavy items to be carried by truck along the ice road.

Ice roads are constructed over frozen lakes where possible. An ice depth of 900 mm has sufficient strength to support 40 tonnes, but ice roads are generally constructed over lake ice which is 2 to 3 metres thick. Ice build up on lakes is accelerated by clearing snow off the ice surface to a width of 30 to 60 metres. The cleared snow is piled into windrows. The weight of snow may cause cracking in the ice, but this does not pose a safety problem in the centre of the road. Driving close to windrows should be avoided. Areas of fast flowing water, likely to cause pressure ridges and leads in the ice, are avoided where possible. Lake sections of winter roads are connected by land-based snow and ice-capped snow roads. These are constructed by compaction of snow, followed by flooding with water to create an ice surface (Adam, 1978).

Speed limits of 30 km/h apply to travel on lake ice roads, to prevent break-up of ice around the edge of the lake. Lower limits may apply in areas where the ice is thin, such as close to shorelines. Vehicles which cause excessive vibration, such as large crawler tractors, are not recommended on ice roads, but should be carried by vehicles causing less vibration.

Maintenance of ice roads involves clearing snow with graders and monitoring the ice thickness and surface. The compacted snow portions of the road will require rut and pothole repair.

Closure of winter roads is dictated by the overland snow road portions of the route. Closure is necessary where the snow has softened to the extent that bogging of vehicles and environmental damage may occur. Limited night travel

may be possible after the road becomes impassable by day, and may be used to retrieve vehicles that may otherwise be stranded for the summer (Adam, 1988).

Mines located close to the all-season road network are found in Yukon Territory and in the Yellowknife area of the Northwest Territories. These mines transport supplies and products in a similar manner to other mines connected to the road network. More care is required for operating vehicles in the long Northern winters, but the system is essentially the same.

Transportation problems in the North.

The harsh climate which exists in the North of Canada poses specific problems with respect to transportation. The region is underlain by permafrost in many areas, which is delicate and very susceptible to erosion. This affects all methods of surface transportation, and surface installations for other transport methods. Maintenance of routes and equipment in cold regions is more costly than in warmer climates, and parts may not be readily available in remote areas. The timing of road maintenance is also affected by climate: the harsh winters prevent maintenance of some facilities except during the short summer. Other work (e.g. some diamond drilling, transport across fragile ground) is best performed during the spring, when the ground is still frozen and there is less environmental impact, but the temperatures are sufficiently warm for working outside.

Another significant problem encountered in the North is the lack of suitable materials for road construction, especially within the Canadian Shield. Gravel deposits are very limited, often being localized in eskers. Since transport of the gravel is costly and often difficult, this is a major factor in transport planning, especially is

determining the location of new transportation corridors. Substandard surface and construction materials lead to added costs in freight transport, e.g. on the north Dempster Highway, where the surface shale causes increased wear on truck tires.

Winter ice roads across lakes are subject to a 30 km/h speed limit to prevent waves building up and breaking the ice connection at the shoreline. This increases travel times.

Permafrost engineering problems.

Construction of roads and port facilities in permafrost regions requires careful planning and design. The existence of permafrost in the Arctic and Subarctic is extremely important for ground stability. Poor planning and design of facilities may cause the permafrost to melt, producing excessive settlement of the structure, often leading to failure. The permafrost ecosystem is also extremely fragile, and thus design criteria are more critical than for mining operations in southern Canada. Destruction of permafrost adjacent to a mine operation or its transportation corridors will have effects visible great distances from the mine.

Maintenance in cold regions.

The maintenance of transportation facilities in cold regions is affected by many of the problems of building on permafrost. Extensive damage may occur due to freeze-thaw cycles and to frost heave, affecting buildings, roads, pipelines and terminal facilities. Marine facilities may experience excessive ice buildup, or damage from sea ice.

Vehicles may suffer greater damage due to ice damage (for marine vessels) and damage caused by winter road

conditions. Periods of isolation during certain seasons require that maintenance schedules be more closely followed than in less remote regions. Roadside maintenance is hampered in winter by cold temperatures and darkness, thus it is more crucial to properly maintain vehicles before embarking on long-distance trips.

Vehicle modifications.

One of the more obvious vehicle modifications in cold regions is the strengthening of marine vessels against ice damage. As previously mentioned, the range and season of an Arctic ship is determined by its rating according to the Arctic Shipping Pollution Prevention Regulations.

For land vehicles, low temperature fuels (e.g. P-60 diesel) and oils must be used during the winter months. In some operations such fuels are used year-round.

Innovative transportation methods.

Many innovative transportation methods have been proposed in the past, in an attempt to solve some of the problems of ground and air transportation in Arctic and other inaccessible regions. These methods include hovercraft, capsule conveyors, heavy lift airships and slurry pipelines. Thus far, no mining company in the North has adopted any of these alternative methods for routine transport of supplies, products, equipment or personnel, primarily because they remain unproven in industry situations and are generally more expensive than current methods.

Hovercraft (also known as surface effect vehicles, air cushion vehicles) of various designs and capacities have been developed for use in the Arctic. These vehicles have

been used commercially in the Arctic since 1966, but have yet to be employed by the mineral industry. Hovercraft may be used over land, ice or water. Designs with a rigid sidewall to the air cushion may only be used in water, those with a flexible skirt may be used on all terrains (Plate 4.2). Obstacles up to 75% of the skirt height can be safely overridden. The most difficult operating conditions for hovercraft are during freeze-up. At this time ice build up on the vehicle can pose severe problems. Hovercraft transportation may be used for personnel, supplies and product transport.

Plate 4.3 and Table 4.2 show some of the commercial hovercraft used in the Arctic between 1966 and 1989. These vehicles were designed to operate in coastal, marine and river environments, over water or ice. Hovercraft have been used for passenger and freight transport on the Mackenzie River and to oil rigs in the Beaufort Sea (Plate 4.4). Large commercial hovercraft have yet to be successfully proven for onshore environments.

Hovercraft tested on Alaska tundra were shown to cause considerable less surface impact than tracked or wheeled vehicles due to lower footprint pressure (Figure 4.6). Five passes of a tracked vehicle over one area caused as much surface damage as fifty passes of an ACV. Low speeds (<32 km/h) cause slight surface damage, speeds of 32-48 km/h will level some surface hummocks, destroying mosses. Speeds greater than 48 km/h cause less surface damage, but increased damage to vegetation (Fancy, 1982). Thaw depths increased two years after testing on multiple pass ACV tracks, due to damage to the organic mat (Zoltai, 1976). However, all damage was much less than for similar movement by conventional transport. ACV use in winter caused no impact over a snow crust of 1/4".

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Plate 4.2 Sectional view of hovercraft. The SEV (surface effect vehicle) has a flexible skirt and may travel over land, ice or water. The SES (surface effect sidewall) has a rigid skirt and may only travel across water. Taken from Amyot (1989).

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Plate 4.3 Arctic hovercraft described in Table 4.2. Taken from Amyot (1989).

Table 4.2 Self propelled hovercraft used in the Arctic between 1966 and 1989. Data from Amyot (1989).

hovercraft name	period of use	gross weight (tonnes)	maximum paylcad (tonnes)	total power (kW)	cushion depth (m)
SR.N6	1966-1977	15	6	1206	1.2
BH.7	1972	61	17	5697	1.8
Voyageur	1973-1987	47	24	3485	1.2
Larus	1981-1987	100	24	4692	0.8
Jeff (A)	1983-1984	177	77	30161	1.2
AP.1-88	1984-1989	41	11	2295	1.4

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Plate 4.4 The SOHIO ACV hoverbarge operating in the Beaufort Sea. This unit was designed to move entire oil rigs and platforms. Taken from Amyot (1989).

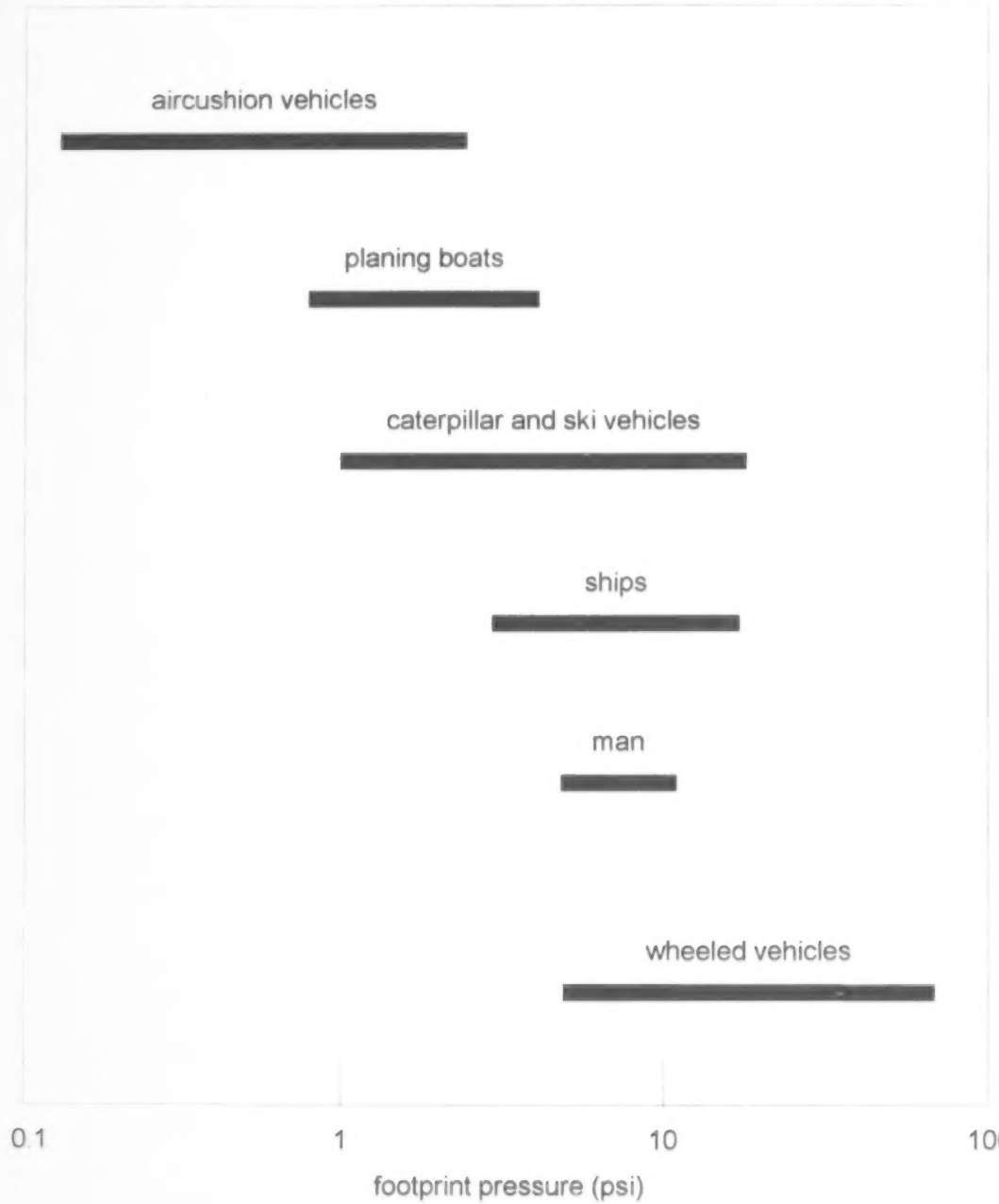

Figure 4.6 Footprint pressures exerted by various transportation methods. After Amyot (1989).

A capsule conveyor (capsule pipeline) has been developed in Japan by Sumitomo Metal Industries and has been successfully operating at the Karasawa open pit limestone mine near Kuzuu City, Japan for 10 years. This system, shown in Plate 4.5, transports limestone over a distance of 3.2 km from the mine to the cement plant. The pipeline is 998 mm in diameter, with an internal air pressure of 0.1 bar. Limestone is carried in three-capsule trains, each capsule capable of carrying 1.6 tonnes of limestone. The capsules run on rubber-tired wheels, located at each end of the capsule on a rotating mechanism. The wheels are set at an angle to the capsule, allowing the wheel assembly to turn and thus produce even wear inside the pipeline. Capsule trains are launched into the pipeline using air pressure from a blower system, as shown in Plate 4.6. Loading, unloading and launching are controlled automatically.

IMC Potash, located in Saskatchewan, seriously considered a capsule conveyor for a proposed new satellite mine at its potash operation. The IMC system will consist of twin 42" diameter pipelines, 11 to 13 km in length. Capital cost was estimated at $800,000 per kilometre of pipeline (1992 dollars). If this project goes ahead and the installation is successful, it may provide an incentive for other mining operations in Canada to consider the capsule conveyor system.

The pneumatic capsule conveyor has proved effective at the Japanese test site, providing 90-94% availability over 16 hours per day. The system has no adverse environmental effects during operation, and the pipeline itself is virtually maintenance free. However, there are some major differences between the test site and possible applications in the Canadian North. Distances would be much greater, and this would require a more sophisticated control system to ensure equal spacing of the capsule trains. Seasonal

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Plate 4.5 Capsule conveyor systems. The upper photograph shows the Sumitomo conveyor filled with limestone. Taken from Kennedy (1993). The lower photograph shows the HTM Global Tubeway System. Taken from Bulk Solids Handling Magazine.

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due to copyright restrictions.

Plate 4.6 Schematic of the loading/unloading system for the Sumitomo capsule conveyor. Taken from Kennedy (1993).

temperature effects would need to be investigated. The high capital costs are a major disadvantage of the present system, although the low operating costs balance this to some extent. The capital cost of the capsule conveyor is $1.0 to 2.0 million per kilometre, which is as much or greater than the cost of all-weather road construction. Operating costs are in the range 1 to 3 cents/tonne-km. The capsule conveyor could be used for long-distance transport of product and bulk supplies, and for minesite materials handling. It is possible that a capsule conveyor could be utilized by many different mines, in the same way as conventional pipelines are shared by oil producers. This would require further refinements to the control system, to enable identification and separation of trains to different routes and/or unloading points. Thus while the capsule pipeline shows potential for the mineral industry, it is not yet proven for use in the Canadian North.

Another pneumatic capsule pipeline system, the Global Tubeway System, has been developed by HTM Global Development in Canada. This system has not yet been put into commercial use, but operates on similar principles to the Sumitomo system.

The Lifting Body Airship (LBA) proposed by Aereon Corporation resembles a futuristic aircraft wing design, with four turboprop engines and is shown in Plate 4.7. The helium-filled aircraft carries the empty weight of the structure. Aerodynamic lift supplied by the engines and ship design carries the payload and fuel. The LBA can carry 150 tonnes in six 40' containers at 150 miles per hour over a distance of 2000 miles. Development costs for the lifting body airship are estimated at $80 million (adjusted to 1994 dollars).

Plate 4.7 The Aereon Lifting Body Airship. Taken from Jackson (1971).

Heavy-lift airships (HLA) consisting of an airship component supplemented by airplane-type wings or helicopter type rotors, were investigated by the BC forestry industry in the 1980's. The vehicle weight and half the payload weight are carried by the balloon, the remaining payload weight is lifted by the wings.

The investigation targeted the use of an airship known as the Cyclo-Crane for short distance (>5 km) transport of timber from steep terrain which is inaccessible to land transport to trucks waiting on a nearby road. This function is currently performed by large helicopters. The Cyclo-Crane is shown in Plate 4.8.

Economic comparisons between the Cyclo-Crane and current helicopter supported logging suggest that savings can be made with the use of the Cyclo-Crane. Cost savings of 34% compared to helicopter logging are suggested by the analysis. Load capacity to gross weight ratios are similar for helicopters and the Cyclo-Crane at approximately 50%. Two other heavy lift airships are described, the Heli-Stat, consisting of four Sikorsky helicopters attached to a central helium balloon, and the Van Dusen LTA 20-1, with a spherical balloon which rotates around a horizontal axis, from which a gondola is suspended. The report recommends further research into heavy lift airships, to bring the technology into production.

Application of heavy lift airships to the Northern mining industry is somewhat different than to logging in BC. Longer distance travel would be necessary, and thus the effects of severe weather would cause more difficulties and possible delays. Van Dusen proposes to build and test a large capacity, long range version of the LTA 20-1, which, if developed, could provide an alternative transportation method for the mineral industry in the North. However, this

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Plate 4.8 The Cyclo-Crane Heavy Lift Airship. Taken from Guimier and Wellburn (1984).

technology is not yet at a stage where it provides a viable, cost effective alternative to tried and tested methods.

Slurry pipeline use in the North is hampered by the seasonal lack of water during the winter, and also by the usual permafrost problems associated with pipeline construction and operation. The slurry pipeline is also limited in use to product transport only, and could not be utilized for bulk supplies and personnel transport.

The use of innovative transportation methods may produce significant environmental benefits in the fragile Arctic ecosystem. However, the extra costs and risks associated with the development and testing of new methods have, thus far, deterred further involvement by the mineral industry. If these methods are to be adopted by Northern mines, they must be thoroughly tested in Northern conditions, and the economic benefits clearly demonstrated. Owing to the large distances involved in Northern transportation, often across remote, uninhabited land, companies are understandably unwilling to commit to costly, unproven, and possibly unreliable technology.

Current expenditures on transportation infrastructure.

Operating a transportation network in the North is costly. Responsibility for construction, operations and maintenance falls on the Territorial Governments. The following sections summarize financial estimates for the Transportation Departments of the Government of Yukon and the Government of the Northwest Territories.

Yukon Transportation Department.

Operation and maintenance budget estimates for the 1994-95 fiscal year were $38.0 million. The largest portion of this ($31.4 million) is allocated to the maintenance of 4735 km of Yukon highways, an approximate availability of $6,631 per kilometre of highway[6]. $2.3 million is allocated to airport facilities. Capital estimates for Transportation Department over the same period were $41.4 million, of which $40.2 million is allocated to highway construction. The largest capital project for 1994-95 was the Alaska Highway reconstruction, with an estimated cost of $32.4 million. The planned work includes a $20 million Transportation Infrastructure Agreement with the Federal Government.

NWT Transportation Department.

Total capital expenditures estimated for the 1995-96 fiscal year by the NWT Transportation Department were $36.3 million. Of this amount, $19.8 million is allocated to highway operation, $0.3 million to marine services, and $9.9 million to Arctic airports. Recoveries were estimated at $4.1 million, with a $3.5 million recovery from Arctic airports. The geographical distribution of this budget is shown in Figure 4.7, and reflects the location of major projects. The $19.8 million capital allocation to highway maintenance provides for approximately 50 km of complete road reconstruction, a further 15 km of paving, and some necessary bridge and culvert replacement. Complete highway reconstruction costs range from $300,000 to $350,000 per kilometre across the Interior Platform, rising to $750,000

[6] In comparison, the Alberta Department of Transportation and Utilities has an annual maintenance budget of $315.9 million for a total provincial highway length of 157,610 km, approximately $2004 per kilometre of highway. The situation in Alberta is more complex than this might indicate, since many highways are maintained by local municipalities, not by the Department, thus these figures do not give the entire picture. There is also greater use (traffic volumes) of the highways in Alberta than those in the North.

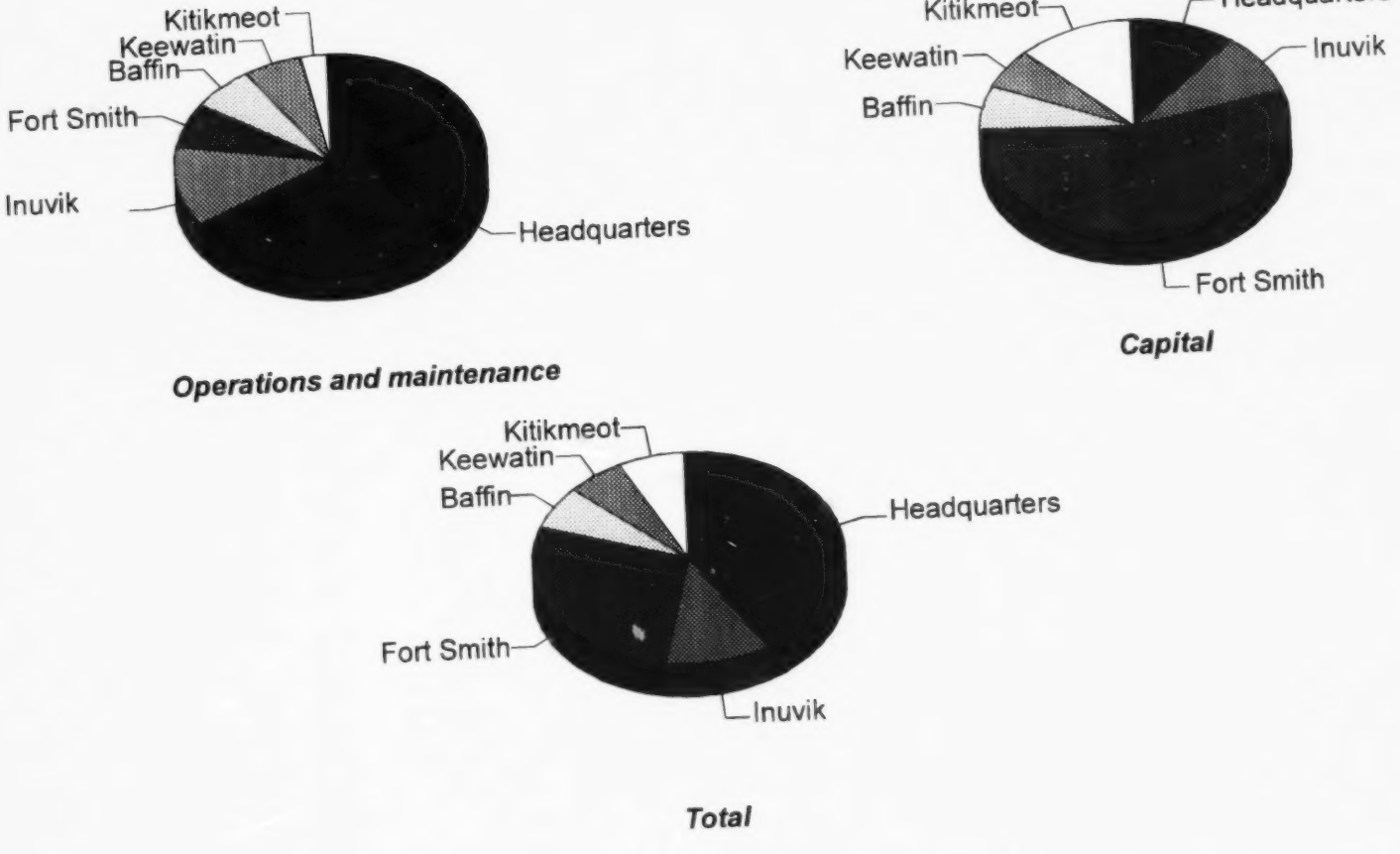

Figure 4.7 Geographical distribution of the transportation budget, NWT. Note that the Fort Smith area has a large capital allocation, due to the reconstruction and upgrading of the Yellowknife Highway.

to $875,000 across the Canadian Shield. The capital budget estimate for 1994-95 was $37.4 million.

The operations and maintenance estimate for 1994-95 was $47.6 million. Of this, $19.9 million was allocated to highway operations ($1.6 million for winter roads, $19.8 million for all-season road maintenance), $4.4 million for marine services and $13.7 million for Arctic airports. Geographical distribution is shown in Figure 4.7. The figure of $19.8 million for all-season road maintenance covers a total road length of 2200 km, an allocation of $8,321 per kilometre. This is higher than the Yukon budget, reflecting the more difficult conditions encountered across the Canadian Shield.

Stated Transportation Department objectives for the 1994-95 fiscal year include:

- to develop and plan for coordinating transportation infrastructure development in the Yellowknife-Izok Lake-Coppermine corridor
- to identify and map environmentally sensitive areas along all-weather transportation corridors
- to develop a strategy for more cost effective alternatives to the existing marine resupply to communities in the Keewatin Region

Major projects include extension of the Mackenzie Highway, at a cost of $1.2 million and the installation of a ferry at Ndulee at a cost of $0.4 million, as part of that extension. $5.3 million is to be allocated to the NWT in 1995-96 as part of the National Infrastructure Program.

The comparative costs of different transportation methods as applied to Northern projects comes under the category of mine economics and will be dealt with in Chapter 6.

Effects of transportation networks on mining and other development, and on the environment.

The main effect of the transportation network on a mineral development is economic. Many currently sub-economic mineral deposits exist in Northern Canada which would be economic were they located in the south. The added cost of northern transportation means that an economic prospect must have a higher grade or greater tonnage than would be required elsewhere. As previously mentioned, every mining operation has transportation requirements which must be met in order for the mine to operate. Where these requirements cannot be met by an existing transportation network, additional routes must be built. The high cost of construction in the North usually precludes the opening of mines distant from transportation facilities.

Northern Governments and industry have historically investigated methods of reducing this extra cost. One method which has been considered is a transportation subsidy. However, like other industry subsidies and tax concessions, this has had varied success and popularity.

Transportation is not only important to the mining industry. It is vital that communities have some method of bringing in supplies and exporting products, as well as routes in and out for travellers. Tourism is also a major consideration when determining transportation agendas. A more extensive and better equipped transportation system will encourage increased tourism, which may be of benefit to the local economy.

Apart from the high cost of construction, the major negative in the transportation equation is its effects on the environment. In many places the fragile Arctic environment cannot support large numbers of people, whether for industry or as tourists. In addition, the process of transportation facility construction may be sufficiently

damaging to the environment as to be unacceptable. Transportation corridors must be considered carefully with regards to environmental impact when making route and method choices.

Transportation planning and development.

Government Policy.

Planning and development of transportation in the North is the responsibility of the Territorial Governments. As previously mentioned, the Yukon and Northwest Territories have different approaches to transportation planning, both historically and at the present time. Prospective mines in Yukon Territory are more likely to be close to an existing road network than prospective mines in the Northwest Territories. Transportation considerations are thus more critical for new mines in NWT.

NWT Transportation Strategy.

In 1990 the GNWT developed a Transportation Strategy, which is a long term transportation planning policy. The strategic objectives of this policy are:

1. Improving current facilities
2. Pushing back the economic frontiers
3. Filling the gaps - transportation subsidies
4. Excellence in transportation programs

(NWT Transportation Strategy document, 1990)

Item 1 involves improvements to current airports, highways, community roads and marine ports. For airports, the objectives include upgrading and relocation of airports not at certification standards[1], improvements to the radio

[1] As defined in the 1974 "Policy for Provision of Air Transportation Facilities and services in the Yukon and Northwest Territories" approved by the Federal Government and assigned to Transport Canada for implementation. Arctic airports are classified as A, B, C or D, according to runway size and available facilities.

systems at Arctic C airports and upgrading of airports for present and future critical aircraft. For highways this includes upgrading, surface improvements, paving, bridge construction and winter road improvements. For marine facilities the policy suggests coordinating activity between Federal and Territorial Government departments, carriers and major customers. Mining operations on the offshore islands are considered major customers.

Item 2 involves developing new transportation networks to support economic development in the North. The Arctic Coast project considered at the end of this chapter is an example of implementation of this policy. Item 3 involves developing a system of transportation subsidies to spread the high cost of Northern transportation more evenly across the NWT. Item 4 involves developing new transportation policies and strategies with regard to excellence in the areas of safety, sustainable development, opportunities for Northern residents etc.

In December 1993 the GNWT updated this policy, producing the Northwest Territories Transportation Agenda. This document reflects the progress which has been made since 1990, and identifies new priorities. The focus for the 1993 document is on short term priorities which can be achieved in the next 2-5 years. Ten major objectives are identified:

1. Accelerate highway upgrading capital program
2. Continue Mackenzie Highway extension
3. Construct Arctic Coast transportation corridor
4. Enhance community local access roads program
5. Upgrade airports to standard
6. Improve air navigation systems
7. Improve local marine facilities
8. Improve marine resupply systems
9. Improve transportation safety
10. Increase local involvement in transportation expenditures

The Transportation Agenda discusses each objective in greater detail. Item 3 relates directly to the mining industry, in that the transportation corridor plan is linked to mineral exploitation in the Slave Geological Province. This case is discussed in detail below.

Case study: The Arctic Coast transportation corridor.

This section considers the various proposals put forth for transportation in the Slave Geological Province, which lies between Great Slave Lake and the Arctic Ocean (Figure 4.8). This area is currently considered to be the primary area for potential mineral development in the western NWT. The Lupin Mine currently operates within the Slave Province, and many other deposits of gold, base metals and diamonds exist.

There is little current road transportation in the Slave Geological Province. The winter road to Lupin Mine is built each year by Echo Bay Mines, and a public winter road from Rae to Rae Lakes and Lac la Martre is built by the NWT Department of Transportation. The proposed Arctic Coast transportation corridor would link Yellowknife with the Arctic coast by means of a road passing through the Slave Geological Province.

The proposed corridor (Figure 4.8) forms part of the NWT Transportation Agenda, published in December 1993. The long term objective for the proposal is to construct an all-season road from Yellowknife to a deep-water port on the Arctic coast. The current proposed port site is Coppermine, but others have been considered. The estimated capital cost for construction of the 650 km road is $570 million, with construction taking place over 5 years. Operation and maintenance of the road is expected to cost $11 million annually. The construction of a deep-water port in the

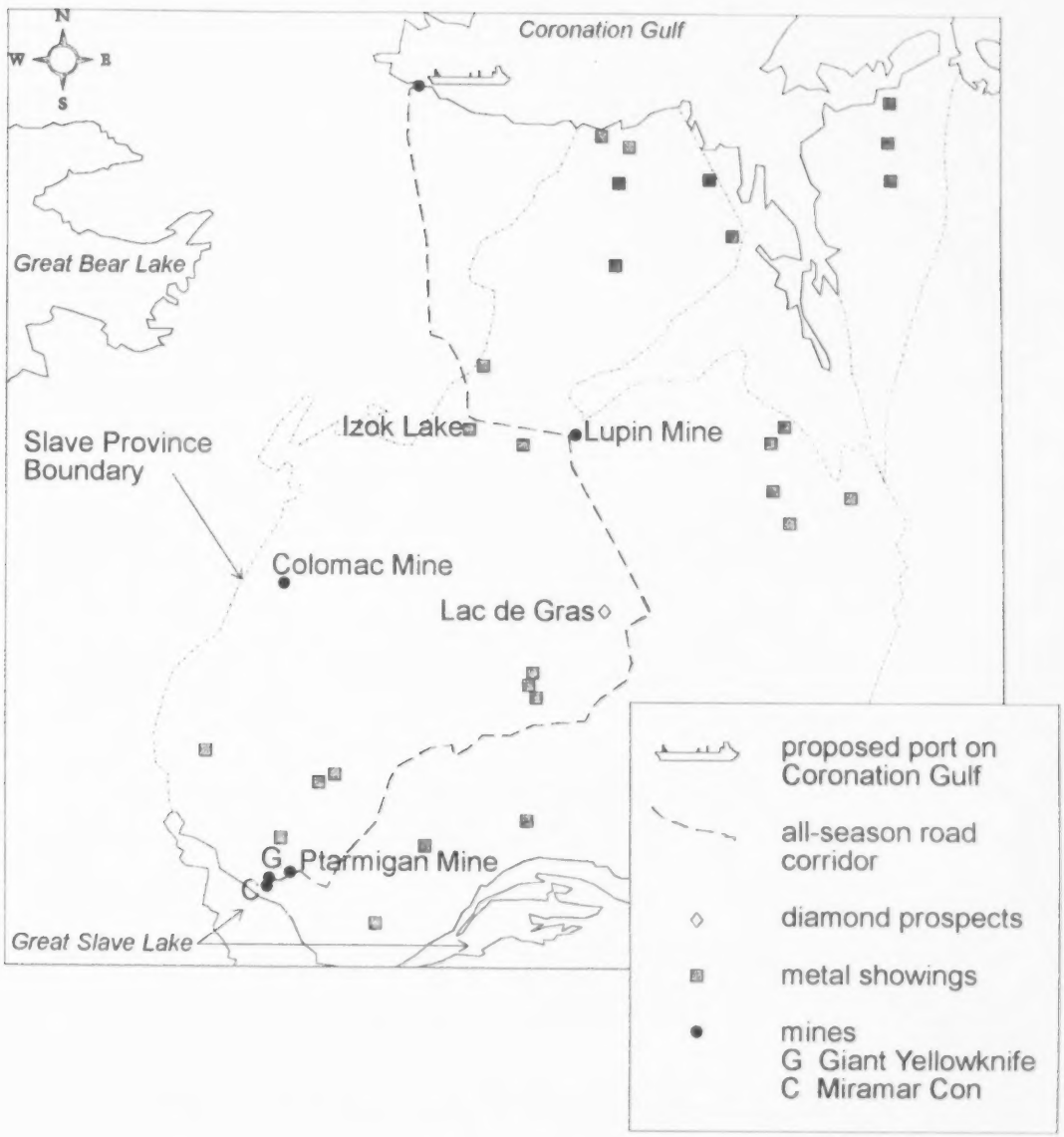

Figure 4.8 The Slave Geologic Province, with mines and mineral projects/showings located, and the Arctic Coast transportation corridor, showing proposed all-season road and port locations.

Coppermine area is estimated to cost $50 million, with an annual cost of $3 million for operations and maintenance. Cost figures are taken from the NWT Transportation Agenda document (1993).

A study in January 1994 by the Conference Board of Canada examines the road and port proposal, and considers the economic implications of the transportation scheme under a variety of mineral development scenarios. The study envisages seven scenarios, with different levels of mineral industry commitment and transportation development. The economic benefits and costs for each scenario are modelled over a 20 year period. Economic benefits for the NWT and for the rest of Canada are detailed. Each scenario considers the possibility of a number of new mines in the Slave Geological Province, including development of the Izok Lake base metal deposit, one or more diamond mines and one or more new gold mines. Extension of the Lupin Mine is also considered.

Land transportation possibilities considered are:

Transportation method	Distance covered	Capital cost (1994 $)
winter road from Izok Lake to Coronation Gulf	230 km	$35 million
all-season road from Izok Lake to Coronation Gulf	230 km	$200 million
all-season road from Yellowknife to Coronation Gulf	650 km	$570 million
all-season road from Yellowknife to Mackay Lake, plus winter road from Izok Lake to Coronation Gulf	650 km total	$185 million

All suggested scenarios include the construction of a deep-water port at Coppermine, and eight-year extension of the current Lupin Mine and the development of the Izok Lake deposit. Other developments proposed are:

1. One or two new diamond mine(s) in the Lac de Gras area
2. One or two new gold mine(s) in the Slave Geologic Province
3. Increased tourism and other renewable resource activity

The capital investments in transportation and mineral development for the different scenarios are in the range $85 million to $620 million (transportation) and $300 million to $2.0 billion (mineral development). Potential increases in GDP for Canada are in the range $4.7 billion to $31.9 billion, for NWT $2.9 billion to $22.5 billion, over the 20 year period (1993 dollars). Potential employment generated ranges from 39,442 to 212,289 person hours for all of Canada, with 11,022 to 62,413 person hours in the NWT over the 20 years.

Yukon Transportation Strategy.

The Yukon Government is currently working on a transportation strategy similar in form to the GNWT document of 1990. At present there is no overall policy. New transportation projects are evaluated on a case-by-case basis. However, as previously stated, the road network in Yukon is much more extensive than in NWT, thus most mineral development projects are located near to the road system. Planning and permitting in Yukon depends upon the nature of the proposed road, and whether or not Government funding is requested.

The Yukon Conservation Strategy, published in 1990, states that the Government of Yukon will design government funded roads to be of benefit to other users after they are no longer needed by the mining industry. This is part of their policy to ensure the best use of mining-related infrastructure.

Summary.

The issue of transportation in the North of Canada involves many different topics. Infrastructure, including transportation, is essential for some forms of economic development, but many more factors must be considered. These include the cost and financing of construction, operation and maintenance; environmental effects; economic benefits and industrial growth and the effects of tourism.

Innovative methods of transportation provide some potential solutions to the issues and problems of Northern transportation. These methods are being refined and researched, and may provide future standards for Arctic transportation. Conventional methods such as road, rail, air and ship are also under constant refinement, to improve accessibility and transportation efficiency in the Arctic. Arctic development, including mineral development, is strongly dependent upon the solution to transportation concerns.

CHAPTER 5: NORTHERN ENVIRONMENT, NORTHERN PEOPLE

Climatic and environmental features of the North.

As mentioned in Chapter 1, definitions of the North depend on the purpose for which classification is being made. For the purposes of this study, the area north of the 60th Parallel which lies within the Northwest Territories and Yukon Territory was considered. Geographically, this area may be divided into Arctic and Subarctic (Figure 1.2).

The Arctic climate is characterized by cold temperatures, little precipitation, short summers and immature, often frozen soils. Permafrost is present at shallow depths, with an active layer thickness range of 0.45 to 1 m. Vegetation consists of shallow-rooted, rapidly maturing plants, and covers only part of the land surface, leaving many areas of exposed soil and rock. Trees such as willow are found, but only reach heights of a few centimetres. The High Arctic has very little vegetation cover, and is often known as the polar desert.

The Subarctic, in contrast, has a well defined summer season. Seasonal temperature variations are great, with extremely cold winter days and hot summer days[1]. This is due to the continental nature of Subarctic locations. Permafrost is less widespread and in some areas discontinuous. Much of the region is covered by boreal forest and wetlands. The 'treeline' between Arctic and Subarctic is actually a gradation from boreal forest through small, stunted trees or 'taiga' to treeless Arctic tundra. Subarctic fauna is more varied than in the Arctic, including moose, beaver and bear, often hibernating through the winter. As well as occurring in the Territories, the

[1] The lowest temperature recorded in Canada was -62.8°C, at Snag, in the Subarctic Yukon, in the summer of 1989 record temperatures of 35°C occurred at Norman Wells in the Mackenzie Valley.

Subarctic also extends below the 60th parallel, into Provincial Canada, beyond the scope of this study.

The effect of low temperatures and little precipitation is a low biological productivity. The natural landscape is slow to recover from damage, whether natural or caused by human impact. This is especially true in areas of permafrost, where minor disruptions can have catastrophic effects.

The effects of current and historical mining operations on the environment.

Any resource-based economy affects the natural environment, due to its extractive nature. Mining is no exception to this. Large scale operations, particularly open pit mines, can have a major visible effect on the landscape and ecology of a region. Public opinion no longer accepts such effects as inevitable consequences of a resource economy. Environmental standards for the mining industry today are much stricter than in the past. The modern mining industry has worked within government regulations to become one of the most responsible extractive industries today. Unfortunately, the label of 'environment wrecker' remains associated with mining, due to past events and less responsible individuals and companies. It is up to the industry to educate the public and provide examples of good environmental management today and in the future, to change this labelling.

Historical mining operations were not subject to the same environmental regulations as today's industry. Early mining operations were based on a 'frontier' mentality, and had little regard for environmental protection. This is evident from the old mining equipment and machinery which can be found rusting and rotting in many areas of the North, and from the acid-draining mine wastes which can also be

found. Mine wastes and litter may be found in all old mining areas, not only the North. Early mining operations tended to be small scale, with limited, localized damage. An exception to this is the Klondike placer mining area. Abandoned mines are prolific in the area, and the environmental effects of dredging are visible from space. As in parts of southern Canada, old mines and prospecting trails exist across much of the North where it is road accessible, especially in Yukon.

As mining operations have become larger, the potential for environmental impact has increased. Major mining developments have been a feature of the North since the consolidation of the Klondike goldfields in 1900. In a 1982 study on mining and the environment[1], 4,298 hectares of land in the NWT and Yukon were considered to have been disturbed by mining wastes[2], representing 11.4% of the total area of the two territories. Of the disturbed land, only 25 hectares were listed as reclaimed land.

Environmental policy and legislation.

Federal environmental legislation affecting mining operations in the Northwest Territories and Yukon includes:

- Territorial Lands Act (including Canada Mining Regulations) (DIAND)
- Northern Inland Waters Act (NWT Water Board/Yukon Territory Water Board)
- Arctic Waters Pollution Prevention Act (DIAND/Transport Canada)
- Fisheries Act (Fisheries & Oceans/Environment Canada)
- Navigable Waters Protection Act (Transport Canada/Coast Guard)
- Environmental Assessment Review Process Guidelines Order (FEARO)

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[1] Mining, Lands Use and the Environment, commissioned by the Lands Directorate, Environment Canada, 1982.

[2] defined as "all lands affected by open pits, strip mines, underground shaft sites, tailings, waste rock, overburden dumps, slag and settling ponds" in the 1982 study.

- Canadian Environmental Protection Act (Environment Canada)
- Yukon Quartz Mining Act, Yukon Placer Mining Act (DIAND)

Authorities responsible for administration of the above acts are shown in parentheses.

Territorial legislation in the NWT includes:

- Environmental Protection Act
- Environmental Rights Act
- Wildlife Act

In Yukon:

- Environment Act
- Water Act
- Yukon Highways Act
- Wildlife Act
- Development Assessment Act[4]
- Historic Resources Act[4]

The application of this legislation to mining development is seen during the permitting process. Any company wishing to begin development of a property must apply for a land use permit. This application is currently managed by DIAND, through a Territorial Lands Engineer. Interested parties: Environment Canada, local community and Native groups, Fisheries and Oceans etc., are consulted by the engineer before the permit is issued. Permits issued by a Territorial Lands Engineer apply to exploration and pre-development work. Specific operation and environmental conditions will be outlined in each permit.

Once sufficient exploration has been completed to allow economic evaluation and development decisions, the company must apply for a surface lease covering the area to be mined. Unlike a land use permit, the surface lease gives the holder sole right to the use of the land in question. An environmental review is conducted as part of this

[4] currently being drafted

process. At any time during the Environmental Assessment Review Process (EARP) the presiding engineer may call for a level II investigation, depending upon the nature and size of the operation, the level of public concern, and uncertainties in possible environmental impacts. The level II investigation takes the form of public hearings, and involves a Regional Environmental Review Committee (RERC). The RERC may recommend that the review be referred to a federal panel. This must be approved by the Minister of the Environment and the Minister of Indian and Northern Affairs, and occurs for projects where impacts are considered severe, or where public concerns are great. If the application is successful, leases are granted by the final review board for the project.

The Territorial Lands Act specifies that an Order in Council from the Privy Council is required for any lease greater than 640 acres in area. This is applied for by DIAND, before such a lease may be issued. Leasing regulations do not specify project duration, these arrangements are arrived at by a process of negotiation. Permits may not be issued which conflict with Treaty rights or land claims agreements, or with Section 35 of the Canada Constitution Act[1].

The Izok Lake project in the Slave Geological Province, NWT (considered in Chapter 4 with reference to the Arctic Coast transportation corridor), is currently in a level II environmental review, with a view to obtaining a surface lease.

[1] *Rights of the Aboriginal Peoples of Canada.* This section recognizes aboriginal and treaty rights, including those rights which exist as a result of land claims agreements.

Yukon Conservation Strategy

The Yukon Conservation Strategy is a plan for conserving Yukon's resources and allowing for responsible, sustainable economic development. With respect to the mining industry, the Government of Yukon plans to work with the Federal Government to:

- reform the Quartz and Placer Mining Acts in accordance with the Northern Mineral Policy
- streamline the administration of licensing and permitting for mining
- provide clear and direct environmental protection methods, including well defined plans for effective reclamation of depleted or abandoned mining sites

The policy suggests that industry can develop internal environmental codes of practice and operating guidelines. Industry can also participate in planning and demonstration projects on environmentally conscious resource extraction, and can work with other groups to improve public awareness of the modern mining industry. On the topic of infrastructure, the Government of Yukon policy focuses on multiple use of infrastructure, such that roads and community facilities are not contingent on mining operations. The policy promotes hiring of personnel from established Yukon communities over the building of new, single-industry communities.

For transportation, the policy advocates multiple use road development and transport planning on a regional basis, as opposed to case-by-case. Environmental, recreational and aesthetic issues are to be considered, as well as economic benefits. Consultation with all interested groups will occur during new road construction or upgrading of current facilities.

Reclamation in the North.

Reclamation is an important part of the mining industry. Without adequate provision for post-production site reclamation, a mining operation cannot proceed. Reclamation requirements are contained within environmental legislation, and their implication is considered during environmental project review.

The process of reclamation is affected by the short summer growing season and the presence of permafrost. Plants must be able to establish themselves rapidly in the reclaimed area, in order to survive the winter. Plants suitable for reclamation of Northern areas are less commercially available than those used in southern mines. This problem is greatest in the High Arctic desert, where few species are found. Permafrost, once disturbed by the mining process, may take many seasons to reestablish itself. This has a major effect on drainage and slope stability, often over very large areas. Ice-rich permafrost may be sufficiently unstable as to prevent the effective economic operation of open pit mines in some areas.

The *Reclamation Guidelines For Northern Canada* (INAC, 1987) identify four 'reclamation regions' in the North based on climate and vegetation. These regions are:

- Polar desert
  This zone is found across much of the High Arctic Islands, and is characterized by a very short growing season (30 frost free days, averaging 0° to 4°C) with little precipitation. Soils are generally saturated, with permafrost within 50 cm of the surface. The organic mat is incomplete, and has less effect on permafrost temperature than in other regions. Vegetation is sparse, and reclamation is limited to drainage and erosion control.

- Tundra
  Tundra is found onshore north of the treeline, above the treeline in mountains, and on southern portions of the High Arctic Islands. The average growing season has 83 frost free days, less than 100 mm precipitation and average temperatures from 3° to 9°C. Vegetation cover is nearly complete, and includes shrubs, heaths, sedges, grasses, mosses and lichens. Permafrost is continuous, generally less than 1 m below surface, and is often

ice-rich. The organic mat is vital in prevention of permafrost degradation, disturbances during operations must be minimized, including drainage and erosion control measures. Reclamation work should include assisted revegetation using appropriate species.

- Woodland

  This zone consists of muskeg and treed areas (white and black spruce, tamarack, alder and willow shrubs). Trees are often dwarfed, except in local sheltered areas. Woodland occurs south of the treeline, in areas of low relief, but also on some mountain slopes. Mean temperatures during the growing season are 10° to 14°C. Permafrost is discontinuous except in the north of the zone, active layer depths range from 80 cm to 2 m. The organic layer is crucial in permafrost protection, and prevention of large-scale soil erosion during spring snowmelt. Drainage and erosion control measures must be taken during operation and reclamation. Revegetation species are commercially available.

- Forest

  This is the most southerly zone found in the Territories. It is mostly covered by spruce, pine, tamarack, birch, aspen and poplar forest, with local areas of bog and fen. The growing season has mean monthly temperatures of 13° to 15°C, and monthly precipitation around 45 mm. The permafrost is discontinuous, and many places are ice-free. In these areas, reclamation practices are similar to those found in the southern parts of the boreal forest. Soils are salvageable for reclamation purposes, and many species are available for revegetation, these can provide a good level of soil protection within the first season. Ice-rich organic soil is found in areas of poor drainage. In such areas, drainage and erosion control is critical, as in the woodland region, especially in areas of moderate relief. Revegitation species are commercially available.

Permafrost is the major difficulty in Northern reclamation. Special steps must be taken to ensure that permafrost degradation is minimized, especially in ice-rich, thaw-unstable soils. Erosion control and contouring processes differ from southern reclamation methods, being primarily designed to prevent slope movement and solifluction. Berms and drainage ditches are usually required. Restoration of the organic mat must occur as quickly as possible to prevent additional degradation.

Revegetation must be carefully planned to ensure maximum germination and survival of the seedlings. In areas where commercial species are unavailable, cuttings must be

taken for revegetation, or seedlings developed by the operation itself.

The resource-based economy of the North creates special environmental issues. Resource extraction is critical to the current Northern economy, but the environmental effects of such activity are greater in the North than other parts of Canada, due to the slow rate of biological growth. Resource operations in the North thus carry a higher responsibility towards environmental protection, including careful extraction management and reclamation.

Local response to development.

Development in the North is often financed and controlled by external (non-local) interests. This is partly a function of the 'global marketplace' which exists today in the industrial world, and partly due to the prevailing attitude towards natural resources i.e. that they are 'owned' by provincial or national governments. Northern projects are more susceptible than many others to this 'external control', due to their remoteness, distance from major industrial and training centres, and the lack of large Northern development firms. Many Northern projects are developed and financed by external (non-Northern) interests, bring in non-Northern workers, and result in little long-term economic benefit to existing communities. Dickerson (1992), in reference to the period 1977 to 1989, states that:

> "...the non-renewable resource industry of the territory has flourished. The mining and oil companies have extracted substantial resources for use in the South or for export."

The result of mineral revenues leaving the North, combined with the subsistence economy of some Northerners is that

many Northern residents, both Native and non-Native, become marginalized by the process of economic development.

The added cost of doing business in the North often makes it unattractive for non-Northern investors and companies. Cost of living comparisons between the North and south of Canada are discussed in Chapter 6. Northern branches and projects are often the first to suffer during recession or difficult economic times. This intensifies the worries of Northern residents, who are concerned about the security of any jobs generated by a project. Coates (1985) states that:

> "Northerners have become accustomed to the abandonment of expansion projects when regional resources have declined in value, or when southern promoters lost interest."

There are many examples of mining projects in the North which have undergone development and then been suspended before production commenced. Mentioned in Chapter 3 are the MacTung project in Macmillan Pass, NWT/Yukon border, and the Midway project on the BC/Yukon border.

A reason often cited for importing workers for Northern projects is the lack of trained personnel in the North. For residents of many remote communities, education and training opportunities are limited within their own community, and extensive travel is necessary to obtain access to such facilities. This may have implications for family life and 'community spirit'. Understandably, there is also a reluctance to travel great distances in order to obtain training for an industry which does not exist in the home community. Thus, historically, many Northern resource industries, including mining, have brought trained workers into the area from elsewhere, many of whom do not remain in

the North after completion of the project, and who have little commitment to the North.

One possible solution to the education question is that of 'distance learning'. This uses interactive television technology (also known as videoconferencing) to enable an instructor to teach a class of students located in another establishment. Students in the distant classroom may ask questions of the instructor, who can respond immediately. Distance learning is different from correspondence courses due to this instructor-student interaction. Interactive distance education is used by the University of Northern British Columbia (UNBC) in Prince George to reach students in its outreach campuses at Quesnel, Terrace and Fort St. John. A four month pilot project was successfully completed in April 1995, and demonstrated the application of distance learning. The technology is also being developed through Community Skills Centres in northern BC, and is expected to be in place at the Kitimat C.S.C. in September 1995. The problem with distance learning is the cost of the technology. Although it is highly suited to small centres where a local college cannot be justified, these centres may not have the financial resources necessary to set up a program. This may improve in the future, and could form part of any training/employment agreement between a mining company and local organizations. It is also possible that mobile classroom facilities could be developed, which could be transported to local communities for the duration of a training course. A less costly alternative to full videoconferencing is audio linking. This is also used by UNBC at Fort Nelson, Chetwynd and Dawson Creek, and may be applicable to some mining company situations.

Significant local opposition to industrial development projects can be found in almost any area. Local residents

may be concerned about the environmental and socioeconomic impacts of the project. The issues described above show that Northern residents have more historical justification for these concerns than in many other areas, and less confidence that the project proponents have any commitment to the North. However, many Northern communities and groups welcome development, and are actively encouraging investment in local development. Current development policies are attempting to involve Northerners in local development, and to develop more community-based economic development.

The mining industry is a poor candidate for community-based development due to its capital-intensive nature. Nonetheless, mineral operations are being encouraged to involve Northerners in development projects, through a commitment to providing training programs and employment for Northerners, and to community consultation. In addition, companies are being encouraged to use local contractors and support businesses rather than those from outside the area.

Northern development remains a difficult and controversial issue. Many Northerners recognize the resource wealth of the North, and the need for some form of development, but wish to maintain local control over resource development. This is evident in many of the Native land claim agreements signed in the early 1990's, which are discussed later in this chapter. As Canada has moved away from its position as a colony, providing resources and riches for the 'homeland', so the people of the North are moving away from their 'resource-based colony' position within Canada, and taking control of Northern development. Native participation and self-government are an integral part of this political shift, and will be discussed below with respect to the Northern mining industry. A detailed

examination of Native issues in the North is outside the scope of this study, and will not be attempted.

Aboriginal participation in the mineral industry.

Aboriginal participation in the mineral industry is generally considered low on a Canada-wide basis. This topic is of particular interest in the Northwest Territories, where aboriginal people make up a majority of the population (61%, NWT Statistics Quarterly, data from June 1991). In Yukon, aboriginal people make up 14% of the total population (StatsCan, 1991 Census data). Many Northern communities in both territories are composed predominantly of aboriginal people.

With respect to general aboriginal employment, in 1991, among adults over 15, participation in the labour force was 59.3% in NWT and 66.3% in Yukon (1991 Aboriginal Peoples Survey, StatsCan). Participation in subsistence activities[1] was 37% in NWT and 28% in Yukon. 25% (NWT) and 26% (Yukon) reported difficulty finding employment due to lack of opportunities located close to their homes. 15% (NWT) and 18% (Yukon) reported difficulty finding employment due to a lack of education or work experience[2].

In 1989 a subcommittee of the Intergovernmental Working Group on the Mineral Industry (IGWG) was formed to study Native participation in the mining industry. This move reflected the concern by governments that Native people were underrepresented within the mining industry. The committee conducted surveys of mining operations located close to Native reserves or communities, and of those communities and

[1] Defined as "adults who report activities which they did to support themselves and their families since January 1990, for which they did not receive money" in the StatsCan report.

[2] With reference to the total aboriginal population over 15 years of age. This was 20,745 for NWT and 3,045 for Yukon at the time of the survey.

other Native organizations. Several brochures were produced, including a *Checklist to Assist Mineral Companies Operating On or Near Aboriginal Lands*; a *Summary of Socioeconomic Agreements*; and a *Communications Guide for Exploration Companies When Working Near Aboriginal Communities*. The brochures contain information designed to enable mining companies to establish a good relationship with local Native groups.

Some of the factors identified by both Native groups and mining companies as contributing to low participation in the industry are:

- lack of experience
- limited access to required education or training
- lack of information about positions and the application and interview process
- language difficulties
- no interest in mining employment
- concerns about the impact of mining development

Lack of experience and limited access to education were cited in survey responses to the IGWG. This is especially true in the North, where the population is thinly spread. For many Northern residents, it is not possible to receive a Grade 12 education without travelling to a regional facility. Many aboriginal people are unwilling to leave their communities for extended periods to attend secondary school. Community members and elders are also concerned about the effect of such absences on traditional and cultural education. Companies responding to the survey felt that they had training programs in place for aboriginal employees, there was less awareness of such programs among Native respondents.

Government permits to mine a deposit often include targets for aboriginal employment 'quotas'. However, the

presence of a mining operation close to a Native community does not necessarily result in a desire for employment among community members. Many aboriginal people choose to follow more traditional lifestyles, and are concerned about the impact of the mine on traditional activities such as hunting and trapping. Wage employment is often considered a seasonal activity, or as a supplement to traditional economies. In communities where a subsistence economy is no longer possible, wage employment may be more actively pursued (IGWG survey responses).

The Nanisivik Mine.

This mining operation had enjoyed a successful relationship with its Native employees, and with the local Inuit community of Arctic Bay, 27 km away. During feasibility and pre start up phases, representatives of Mineral Resources International, owners of Nanisivik Mine, engaged in meetings with Arctic Bay community members. The mine was initially planned as a fly in/fly out camp operation, but in keeping with Federal Northern development policies of the time (1974), was changed to a townsite development. Nanisivik Mines Limited, who operate the mine, applied to the Federal Government for financial assistance for townsite, and transportation infrastructure construction.

Some of the provisions involved in the granting of assistance were:

- the establishment of the Strathcona Sound Monitoring Committee (SSMC), composed of company, government and Native representatives
- a target of 60% Native employees at the mine by the third year of operation[6]
- commitments to training programs

The SSMC was formed in 1974 and has been active during the life of the mine. It has dealt with problems such as alcohol availability within the communities of Nanisivik and Arctic Bay, Native employment levels and programs, and shipping routes.

The initial figure of 60% Native employment proved to be unrealistic. Native employment levels have been 21-27% through the life of the mine[7]. A 'job sharing' scheme has been introduced for employees from Arctic Bay, which allows Inuit workers to take leave-of-absences from employment without penalty. Turnover of Inuit employees is greater than for southern employees, but the job sharing policy maintains a pool of local employees, who fill a certain number of vacancies. The mine provides extensive training for local Native employees. A bus service between Nanisivik and Arctic Bay is provided for Arctic Bay employees. Inuit employees from communities other than Arctic Bay live in the Nanisivik townsite, as do southern employees. These employees are given a two week leave-of-absence in the

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[6] This figure was based on a presentation for government assistance for the Nanisivik project by Watts, Griffiths and McQuat, the consultants employed by Mineral Resources International to produce a feasibility study for the mine. The original presentation contained the phrases: "...it is our hope that we will eventually be able to have as many as 100 permanent Eskimo employees on staff at Strathcona Sound, or approximately 50% of the total workforce. Large numbers of other Eskimo would gain employment in various service industries that would be required if a full mining community was established at Strathcona Sound...".

[7] In comparison, Native employment at the Syncrude operation in Fort McMurray, Alberta, is approximately 7.5%.

middle of the standard thirteen week work rotation. Transportation is paid to their home community for this period. Southern employees (non-Native) work thirteen week work rotations with three weeks 'outside'. Transportation for southern employees is paid to their point of hire.

Land claims and land use guidelines.

There are few zoning regulations in the Northwest Territories and Yukon with respect to land use. Exceptions to this include parks and wildlife preserves, which are considered as lands removed from staking, and also from further development. With the increasing number of Native land claim settlements, land zoning is becoming part of the Northern experience.

The Nunavut agreement includes zoning of lands. The area covered by the agreement is shown in Figure 1.3, and is known as the Nunavut Settlement Area. Environmental review on jointly controlled land will be conducted by the Nunavut Impact Review Board. This board will:

- screen projects for review
- define regional impacts and a sphere of influence for a project
- review ecosystemic and socioeconomic aspects of a project
- set conditions for project approval

The Nunavut agreement also contains provisions for resource royalty sharing between government and Inuit. 50% of the first $2 million of resource royalty paid to the government plus 5% of additional resource royalty is to be paid to the Nunavut Trust, for the benefit of Nunavut Inuit. With respect to development management, the Nunavut agreement provides that the proponent of any resource development

shall consult a designated Inuit organization with respect to:

- Inuit training and hiring
- employment rotation
- labour relations
- business opportunities for Inuit
- accommodation and recreation on the project site
- safety, health and hygiene
- language of the workplace
- identification, protection and conservation of archaeological sites and specimens
- research and development
- Inuit access to project facilities, such as roads and airstrips
- wildlife disruption and environmental issues of particular importance to Inuit
- outpost camps
- flow of information between project proponent and Inuit
- coordination with other developments
- any matters considered important to the project and Inuit

(Nunavut Final Agreement, 1993)

The Gwich'in and Sah'tu Dene and Metis agreements place emphasis on comanagement procedures. Under these agreements, land use permits are issued by a board having a composition specified in the agreement, not by a single Territorial Lands Engineer. The composition of the Environmental Impact Review Board panel set up to examine a particular project is specified in the Gwich'in agreement as:

- 50% of the members of the EIRB panel shall be nominated by the Gwich'in Tribal Council for projects wholly or predominantly within the settlement area defined in the agreement
- One member of the EIRB panel shall be nominated by the Gwich'in Tribal Council for projects partially within the settlement area

The environmental impact review shall have regard to:

- protection of existing and future economic, social and cultural well-being of the residents and communities in the Mackenzie Valley
- protection of the environment from significant adverse impact from the proposed development
- in cases where the proposed development will likely result in a significantly adverse impact on the environment, the need for mitigative or remedial measures

(Gwich'in Final Agreement, 1992)

With respect to subsurface development and resource royalties, the agreement specifies that 7.5% of the first $2 million payable in resource royalties, plus 1.5% of any subsequent amount shall be paid to the Gwich'in Tribal Council. Prospectors conducting exploration projects which require a land use permit shall consult with the Gwich'in Tribal Council on:

- environmental impact and mitigative measures
- impact on wildlife harvesting, and mitigative measures
- location of camps and facilities, and site specific planning
- maintenance of public order, including liquor and drug control
- Gwich'in employment, business opportunities and contracts, training, orientation and counselling for Gwich'in employees, working conditions and terms of employment
- expansion or termination of activities
- process for further consultation
- any other matters of importance to Gwich'in or the project

Consultation on these issues must also take place before development or production commences.

The Sah'tu Dene and Metis Final Agreement, which represents Dene and Metis of the Sahtu Region of the Mackenzie Valley, is modelled on the Gwich'in agreement and contains similar provisions with respect to environmental review, subsurface development and resource royalty payments.

The Umbrella Final Agreement between the Council for Yukon Indians (CYI), Canada, and Yukon Territory specifies that development shall be monitored by the Yukon Development Assessment Board (YDAB) which shall be composed of nominees of the government (50%) and of the Council for Yukon Indians (50%). The YDAB shall appoint panels to review proposed development. The panel composition will be determined by the location of environmental or socioeconomic effects of the project thus:

• primarily on settlement land:	2/3 CYI nominees 1/3 govt. nominees
• primarily on non-settlement land:	1/3 CYI nominees 2/3 govt. nominees
• not primarily on either land type: but affecting both types	1/2 CYI nominees 1/2 govt. nominees

This Umbrella Final Agreement also includes provisions for resource royalty sharing. 50% of the first $2 million of resource royalty received by the government, plus 10% of subsequent royalty revenue. This revenue is payable only to First Nations who have entered into agreements with the Government of Yukon during or prior to the year of receipt. The Government of Yukon has entered into agreements with the Vuntut Gwitchin First Nation, the Teslin Tlingit Council, the First Nation of Nacho Nyak Dun, and the Champagne and Aishihik First Nations under the terms of the Umbrella Final Agreement.

Specific local agreements between Native groups and individual mining companies also exist. Anvil Range Mining and the Ross River Dena Council signed a socioeconomic agreement in January 1995, with respect to the Faro lead-zinc mine. Anvil Range Mining plan to reopen the Faro Mine, which they purchased from the Curragh Resources, now

in receivership. The socioeconomic agreement was ordered by the court handling the Faro receivership (*The Northern Miner*, March 6, 1995). The agreement includes provisions by Anvil Range for training, employment, apprenticeships and scholarships. Instead of rigid quotas for Native hiring, the agreement creates opportunities for band members seeking employment at the mine.

The Ross River Dena Development Corporation is also negotiating with Cominco Resources with respect to the Kudz Ze Kayah polymetallic exploration project. Cominco has a history of such agreements, being involved in partnership with the NANA[10] Regional Corporation at its Red Dog Mine in Alaska. The 1982 Cominco/NANA agreement contains provisions for employment, royalty payments, training and issues relating to subsistence activities.

An economic development agreement is being negotiated between the Carmacks Little Salmon First Nation and Western Copper Holdings, with respect to the Carmacks Copper Project mentioned in Chapter 3. This agreement has been developed as exploration on the property took place. This 'advance negotiation' is rare in Northern industry, and represents evidence of increased attempts to involve local First Nations in industrial development.

Traditional lifestyles and mining development; a conflict?

This topic is a controversial and sensitive one, the specifics of which are outside the scope of this project. Part of the sensitivity arises from the view of aboriginal peoples as 'noble savages' which has been perpetuated by some anthropological works and the popular press.

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[10] Northwest Alaska Native Association, formed in 1966 for land claim negotiations. The NANA Regional Corporation was incorporated in 1972 after settlement of the claim with the US Government.

Community-based development schemes based on renewable resources have been suggested as appropriate for the North, especially in Native dominated areas. In the 1974 Mackenzie Valley Pipeline Enquiry report, Justice Thomas Berger stated that non-renewable resource development in the Mackenzie Valley be postponed until a sufficient local economy was established, with both cash and non-cash sectors. However, many Native organizations and white policy advisors see major industry as a revenue generating opportunity for Northern Natives; this is evident in the resource royalty clauses found in land claim agreements signed in the 1990's, and in agreements between Native organizations and individual mining companies, as mentioned above.

The compatibility of Native culture with industrialization is a topic which could form a research paper by itself. As with southern Canadian peoples, there is no consensus on the merits of industrial development among Northern Native peoples. Just as conflict exists between environmental activists and resource developers in southern Canada, so there is conflict within Northern society concerning industrial development. The main challenge for all the peoples of the North is to overcome the colonial status of Northern Canada and become involved in Northern self determination and development.

CHAPTER 6: THE ECONOMICS OF MINING IN THE NORTH

> "The meek may inherit the Earth, but not the mineral rights."
>
> source unknown

The benefits and costs of mine development.

Costs associated with mine development begin with the grassroots exploration phase and end with final decommissioning. Mining companies today must plan budgets and make investment decisions based on this time period. In the past, salvage and reclamation was often omitted from the budget, modern legislation requires that environmental considerations be included from the beginning.

While the overall costs of mining in the North are greater than those of comparable southern mines, the benefits are equal. All mineral commodities are sold on world markets, where commodity values are determined, often fluctuating wildly over short time periods. Mining economics and financing is a risky topic in any location, but the added costs of northern operations increase the risk associated with a venture.

Operating costs in the North.

As mentioned above, mining operations in Northern Canada incur additional expenses over the cost of running a similar operation in the south. The cost of living in the North is generally high, this affects all industries operating there. Food costs are 27% higher in Whitehorse and 31% higher in Yellowknife than the Canadian average (Yukon Statistical Review, Feb. 1995). Cost of living in the NWT is between 35% (Yellowknife) and 110% (Sachs Harbor, Colville Lake) higher than that in Edmonton, depending upon location within the NWT. In the communities of Nanisivik,

Arctic Bay and Resolute, which are located close to operating mines, the cost of living is 65% to 70% higher than in Montreal (NWT Bureau of Statistics, 1994). A large proportion of the increase in costs in the North is directly related to transportation and freight charges. Transportation costs at Northern mines range from 30-40% of the cost of mining the ore. The cost of transportation is also reflected in passenger airfares, which are up to 40% higher than for flights of similar distance between southern destinations. All these higher costs translate into higher operating cost for any Northern industry, and mining is no exception to this.

Mining equipment.

Mining equipment suppliers are based in southern Canada, the US, and Europe, with most equipment being brought to Canada from the US or overseas. Thus, for Canadian mines, a freight charge is applied for delivery of large equipment. When equipment must be transported to Northern or remote locations, the freight charges are higher than for delivery to more accessible mines. For example, the cost of transporting a 240 ton truck to a mine in northern BC may be 50% higher than transporting the same truck to a southern BC mine. For mines in the Territories, this percentage increases further. The cost for transportation of large excavators from Vancouver to Whitehorse is between $35,000 and $40,000. For a cable shovel, Vancouver-Yukon transportation may be $1 million.

The Izok Lake deposit: transportation choices.

Transportation choices available to a mineral developer will be considered during feasibility analysis. This analysis will identify the potential methods and routes

available and consider their advantages and disadvantages. Metall Mining Corporation (known as Inmet Mining Corporation since May 1995) conducted such a study into the development of their Izok Lake base metal property. This property is a pivotal part of the GNWT Arctic Coast transportation corridor proposal discussed in Chapter 4. Transportation methods considered in the Izok study range from conventional to unconventional, and encompass both land-based and marine routes. Each possibility was ranked in terms of economics, with a winter road from the proposed minesite to a deep-water port on the Arctic Coast being considered as a base level. These rankings are given below:

winter road to Arctic Coast port	100
all-weather road to Arctic Coast port	101
winter road to Yellowknife	106
all-weather road to Yellowknife	111
hovercraft	133
railway to Arctic Coast port	139
capsule conveyor	142
railway to Hay River	235
airship	239[1]

This list shows that the projected cost for all road options is within one range, and that other transportation methods are more costly than the road alternatives. Hovercraft, capsule conveyor and a northward railway are all viable, being only 30-40% greater in cost. It is notable that the costs for innovative transportation methods considered are not significantly higher than conventional (railway) proposals. However, road transportation is likely to be chosen by companies working within the Slave Province.

[1] Figures taken from presentation by Hugh Wilson of Metall Mining Corporation (now Inmet) to the Edmonton Branch of the CIM, March 1995.

Transportation infrastructure development, who pays?

The development of transportation infrastructure is often a major part of the cost of putting a mineral property into production. Where the infrastructure is required specifically by the mine, and will only be used by the mine operators, then it is obvious that the costs should be borne by the operating company. The situation is less obvious in the case of infrastructure which could benefit a number of users, or which may encourage industrial development of a region. An example of such an infrastructure project is the Arctic Coast Transportation Corridor through the Slave Geological Province, discussed in Chapter 4.

The Conference Board of Canada report on the Arctic Coast Transportation Corridor (ACTC) cites many possible industrial developments within range of the corridor. In the maximum development scenario, 5-7 new mining operations would open, the life of the Lupin Mine would be extended, and there would be increased tourism and other renewable resource activity. These developments will be influenced by the existence of road access, but the precise relationship is complex. The multi-purpose nature of such a road development leads naturally to questions of funding.

A proposal by the Government of the Northwest Territories was sent to the Minister for Indian and Northern Affairs in spring 1993, concerning the development of the ACTC road. This proposed the use of public funding for construction of the road, and a deep-water port at Coppermine. Although there are many exploration projects which could benefit from the road, the most advanced is the Izok Lake base metal property owned by Metall Mining Corporation. Metall has stated that this project will not provide sufficient return on investment without public funding for the infrastructure development, and will not go

ahead. The Izok project itself requires construction of a deep-water port at Coppermine, and a road from the Izok site to Coppermine.

Controversy over the funding of the ACTC comes from many angles. Should the government be committing itself to major infrastructure projects without the certainty of mineral development? Is the development of the Slave Province desirable? With uncertain metal prices, will there be sufficient revenue generated to justify the public investment? None of these questions have clear answers. What is clear, however, is that all developments in the Slave Province are interrelated. At present, with no transportation infrastructure in place, the costs of mineral development are high. With the construction of a road, costs will decrease, making properties in the Slave more attractive to developers. However, no single project is sufficient to finance the transportation proposal. The Izok project has received much focus, due to its relatively advanced state of development, but will not go ahead without public transportation funding.

The issues surrounding the development of the Slave Province and the ACTC are a major factor in Northern mineral development. The Federal Government is less willing today than in the past to commit millions of dollars to infrastructure development without some assurances of economic benefits, having learned from the oil and gas exploration during the 1980's, which led to little development and production. In addition, many NWT residents are concerned about the impact of large-scale industrial development on the livelihood of local residents, and on renewable resource harvests. Modern Northern development is likely to follow a very different path than in the past, and to require innovative and co-operative action from all concerned.

Northern Economic Policy.

Economic policies in the North are continually being reviewed, as in the rest of Canada. The current focus of economic policy in both territories is towards financial independence from the Federal Government, and thus greater territorial and local control over development.

In 1988, the Yukon Government published the Yukon Economic Strategy, as part of the YUKON 2000 program. The major thrust of the policy was to enable the Yukon to become more self-reliant, with the right to develop a Yukon economy of benefit to Yukoners. Responsible resource development was highlighted as an important area of economic potential. A mix of economies, including resource-based industry, small business, government and the non-wage economy (e.g. subsistence living, voluntary services and household work) should all be part of the present and future Yukon economy. Four goals were identified by the policy:

- the option to stay in the Yukon
  development should offer Yukoners the chance to remain in the Yukon, with opportunities to support themselves and their families.

- control of the future
  including more regional and local decision making, and a higher level of Yukon ownership.

- an acceptable quality of life
  wages, business opportunities and services comparable with the rest of Canada without sacrificing the Yukon environment or the potential for subsistence living.

- equality
  for all Yukoners, including those groups who do not participate fully in the Yukon economy at present.

The Strategy identifies the three major revenue sectors in the present Yukon: mining, tourism and government. These industries should be supplemented by others such as manufacturing, finance, renewable resources and processing.

Timely settlement of land claims and Yukon control over Yukon resources should create a more stable investment climate in Yukon. Mining is identified as a "particularly important employer", and the policy states that the government will continue to support viable resource development, concentrating on those projects from which maximum benefits to Yukoners accrue over longer periods of time. Part of this support involves providing communities who are affected by major resource developments with the necessary training, jobs, infrastructure and business opportunities to enable community participation in the project. This is to be achieved through development agreements with project proponents, or through development assessments.

With respect to infrastructure, the Strategy proposes development of a long-term transportation plan, this proposal is mentioned in Chapter 4. One of the medium-term priorities is to reduce the cost of freight transportation to and from Yukon. Resource access roads should be developed, with priority given to multiple-use roads. The government aims to involve the mining industry in setting priorities for implementation of transportation projects.

The NWT economy well illustrates the 'dual economy' of cash and non-cash sectors. The 1988 NWT Economic Review and Outlook states that:

> "The Northwest Territories is rich in natural resources, but the economy remains poorly integrated and diversification has been confined to the development of service businesses which are primarily dependent on government."

The mining industry in the NWT is the largest private-sector employer, the biggest exporter and the greatest contributor to corporate profits. Miners are the highest paid wage

group in the NWT. The future directions of the NWT economy are considered to be mining, tourism, and some renewable resource development. As for Yukon, the NWT aims to diversify its economy and gain more control over development in the territory. However, the transportation and distance barriers are greater in the NWT than in Yukon, thus the diversification and devolution are likely to take more time. The proposals for diversification put forward in the Nunavut settlement may improve local economies by decentralization of government services, but the effect this will have on the private sector is not yet known.

The importance of the mining industry to the Northern economy.

For many decades, resource industries, dominantly mining and petroleum, have been touted by Northern and national governments as the answer to all economic problems in the North, and in Canada as a whole. The mining industry has certainly played a crucial part in Northern development since the colonization of the North. Without the mineral industry, many of the infrastructure developments in the North would not exist. Non-Native settlement in both territories can be said to have had a close relationship with mineral development and the mining frontier. The territorial reliance on resource industries for revenue generation remains today, with 17% of the 1993 Northern GDP being derived from mining.

Despite this historical reliance, there are many who wish to see mining in the territories curtailed or stopped. Many such people are concerned about the environmental effects of the mineral industry, and see the North as a vast wilderness, which should be preserved intact, without the intrusion of industrial development. Although there are residents of the North who share this view, the concept of

'wilderness' is relatively new to many Northerners. Traditional Native lifestyles are intimately connected to the land and to the environment, however, the western concept of wilderness preserves is not part of this balance. Many of those who see the North as a preserve are as colonial in this thinking as the first pioneers, who had little concern for the impact of their exploration on indigenous peoples.

The underlying reality of life in the North differs little from that elsewhere. People need food, shelter and clothing. For this, a source of income is necessary. The mineral industry provides one means for the North to regain control of its own development. There are other viable methods for revenue generation in the North, no area should build its economic foundation upon one resource. The great mineral wealth of the North is beginning to be recognized by its residents, who wish to be part of their own future.

CHAPTER 7: CONCLUSION

Summary.

Northern mineral development and transportation have been closely linked throughout the non-Native development of the North. Much of the North has been 'opened up' for the purpose of, and as a result of mineral exploration. Early exploration was confined to areas easily accessible from the sea or the river system. With the development of air transportation, more areas became available for exploration and potential exploitation. The early mines were individual claims, usually precious metals, which were worked with manual, small scale methods. As the Northern mining industry matured and diversified, other minerals were exploited, larger claim blocks were worked, and mining methods were mechanized. Political thinking and increased development led to changes in Northern regulations and government, but mineral resource development remains largely in the control of the Federal Government. Transportation is the responsibility of the Territorial Governments.

At the time of this study, Northern mineral development appears to be regaining health after a slow period. Exploration is increasing over the levels in the early 1990's, and many new mining projects are being planned. Many Northern residents wish to encourage and become involved in mineral development in the North. There are currently no active hard-rock mines in Yukon Territory, although the Faro Mine is planning to reopen, and the Brewery Creek project is in development. In the NWT, there are seven active mining operations, and the Izok Lake project is under development.

Native land claims are being settled in the North at a faster pace than in the past. This is removing many areas

from 'uncertain' status with respect to development. The land settlements include provision for local input and control over developments within the settlement area. Improving the certainty of land status in the North will provide greater incentive for exploration.

As previously mentioned, the mining industry forms one of the cornerstones of the Northern economy, and is its largest private-sector employer. The mineral potential of the North is recognized by many, and Northern people are beginning to become more involved in resource development. The current trend is towards more coordinated development in the North, with Northern residents playing a more active role. In this manner, the Northern territories hope to increase local and regional participation in future decision making.

Implications and recommendations.

For the North to achieve sustainable development which benefits community and regional interests, and strengthens the Northern economy, there must be increased communication and cooperation. Mining is important to the Canadian Territories as a source of both income and employment. All stakeholders: industry, government, local residents and Native groups must participate in this cooperative effort. On a national level, this has begun with the Whitehorse Mining Initiative Leadership Council Accord, adopted on September 13, 1994. Further cooperation is necessary to ensure that mining in the North produces the maximum benefit to all. A balance is necessary between land-based, subsistence economies and wage-generating economies, such as mining. The fragile Arctic ecosystem must be protected. This balance must be achieved without imposition of an

excessive regulatory regime, which increases the cost of exploration and development, and discourages exploration activity.

As the wage-generating sector of the Northern economy grows, transportation will become a more important issue. Planning transportation improvements and new facilities must be aimed at providing maximum benefit at minimum cost, including socioeconomic and environmental cost. Cost recovery methods, such as toll roads, should be examined where major infrastructure is required in an area, such as in the Slave Geologic Province today.

The mineral industry offers great potential for the development of the North. However, it is important for the people of the North to learn from the past, and to diversify the Northern economy by developing other sectors. This need is reflected in the economic policies of the North, which encourage development of a diverse industry base.

The Northern mineral industry has evolved considerably since early non-Native exploration, when the mineral potential of the North was first recognized. With increased involvement of Northerners in both decision making and in the development/production phases of responsible mining operations, economic conditions in the North will improve. The mining industry has changed and adapted, but remains an important part of life in the North.

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GLOSSARY OF TERMS AND SYMBOLS

Ag	silver.
Au	gold.
boom and bust	an economic cycle where the economy of an area grows rapidly and then shrinks rapidly. Often occurs in areas dependant upon export of a single commodity, as demand for that commodity varies.
Cu	copper.
Fe	iron.
grassroots exploration	the process of searching for previously undiscovered mineral occurences by geophysical, geochemical and field studies.
Mo	molybdenum.
Pb	lead.
permafrost	ground which is permanently frozen. May be defined as: *a soil or rock material with or without included water that has remained at or below 0°C continuously for two or more years.* 40-50% of the land area of Canada is permafrost.
'pioneer' road	the initial Alaska Highway, constructed in eight months in 1942 by the US Army Corps of Engineers is referred to as a pioneer road. This road followed a convoluted route, and was rough and boggy in places, which resulted in poor driving conditions and frequent stuck vehicles.

placer Au	alluvial deposits containing an economic concentration of gold.
subsistence economy	an economy which is not dependant upon wage employment or other cash exchanges, where necessary food, supplies and services are obtained through hunting, gathering, exchange, barter and other non-cash methods.
W	tungsten.
Zn	zinc.

APPENDIX 1: MINING COMPANY QUESTIONNAIRE RESULTS

This appendix contains a copy of the questionnaire sent out to mining companies. The results of the survey are also shown. 174 questionnaires were sent out, to major and junior mining companies, including all those with known mining operations in the NWT and Yukon Territory. Of these, 8 were returned unopened, 49 completed questionnaires were received and two companies replied that they were not in the mining industry, and were thus unable to assist. In summary:

Questionnaires sent:	174	(100%)
Completed replies:	49	(28.1%)
Uncompleted replies:	2	(1.1%)
Undeliverables returned:	8	(4.6%)

The remainder (66.1%) of the questionnaires were unanswered.

The following pages contain the text of the survey and a summary of the responses received. For questions where a yes/no answer was given, the number of 'yes' and 'no' replies is shown, followed by the percentage of each, out of the 49 replies. The 'don't know' replies include those who did not answer the question. The sum of all answers for such questions is 49 replies (100%). For the questions where a list of alternatives was given, with the instruction to check all that are appropriate, the number of checks is recorded (maximum 49). The percentage of replies in which that alternative was checked is also shown.

Where boxes were filled, the results are not shown, except in the case of areas considered more favorable for mining investment. These are shown, with the number of responses, divided into the following areas: Canada (excluding NWT/Yukon); USA and Central America; South America; Europe; Africa and Asia.

Interpretations drawn from the questionnaire may be found in Chapter 3.

Department of Mining, Metallurgical and Petroleum Engineering
University of Alberta

Mining Development in the North of Canada
Company Activity in the North - Questionnaire

Particulars:

Company Name:

Mailing Address:

Contact Person:

Telephone: Fax:

(if further information is required)

In the following questions, please circle the appropriate response or fill in the boxes. Confidentiality will be maintained. Information gathered is to be used statistically.

What commodities is your company involved with?
(please check all which apply)

40	82%	precious metals
29	59%	base metals
20	41%	diamonds
4	8%	industrial minerals
2	4%	coal
1	2%	uranium

Current Activity in the North:

Does your company currently operate a mine in the North of Canada? (NWT/Yukon)

yes	5	10%	Location and name:		
no	44	90%			

Is your company currently engaged in exploration activity in the North of Canada?

yes	37	76%	Location of project(s):		
no	12	24%			

Does your company have any plans to become involved with Northern projects in the future?

yes	34	69%	don't know	4	8%
no	11	22%			

Would your company rate the North of Canada as an attractive mineral exploration target area?

yes	38	78%
no	11	22%

Which of the following items influence the above rating? (check all which apply)

16	33%	isolated location
11	22%	sparse population
26	53%	development regulations and legislation
10	20%	climate
14	29%	Native land claims
22	45%	available transportation facilities
21	43%	available infrastructure
25	51%	other:

Do you feel that the exploration environment in Northern Canada is favorable for investment?

yes	37	76%	don't know	2	4%
no	10	20%			

Do you feel that mining in the North is adequately promoted by Canadian Governments?

Federal:	yes	9	18%
	no	32	65%
	don't know	8	16%
Territorial:	yes	25	51%
	no	18	37%
	don't know	6	12%

What other area(s) of the world do you consider more favorable for mining investment?

South America	26	53%
Africa	12	24%
USA/Central America	9	18%
Asia	6	12%
Canada (non-Northern)	4	8%
Australia	2	4%
Europe	1	2%

Does your company consider exploration projects in the North of Canada a priority?

yes	18	37%	don't know	2	4%
no	29	59%			

Do you feel that environmental concerns are more restrictive concerning transportation in the North?

yes	25	51%	don't know	5	10%
no	19	39%			

Transportation and infrastructure:

Do you consider availability of transportation networks to be a major factor in mineral resource development?

yes	45	94%
no	3	6%

Do you consider that the available transportation network in the North of Canada discourages mineral development?

yes	39	80%	don't know	2	4%
no	8	16%			

How do you supply current Northern exploration or how would you supply such exploration (please check all which apply)

44	90%	air
17	35%	all weather road
28	57%	winter road
5	10%	other road
11	22%	sea
5	10%	river
2	4%	rail
0	0%	other:

In considering the development of Northern operations, what method(s) of transportation would you examine for brining in mine supplies?

36	73%	air
41	84%	all weather road
39	80%	winter road
12	24%	other road
23	47%	sea
8	16%	river
10	20%	rail
2	4%	other:

In considering the development of Northern operations, what method(s) of transportation would you examine for carrying the mineral commodity from mine to smelter/market?

19	39%	air
37	76%	all weather road
23	47%	winter road
10	20%	other road
26	53%	sea
10	20%	river
12	24%	rail
2	4%	other:

Have you undertaken any transportation feasibility studies with respect to Arctic environments?

yes	8	16%
no	41	84%

Have you considered any alternative transportation methods?

yes	6	16%	method(s):
no	41	84%	

With respect to the development of a mining operation in the North, what methods of power supply would you examine?

29	59%	hydro
41	84%	diesel (trucked in)
11	22%	diesel (pipeline)
9	18%	diesel (helicopter pod transport)
17	35%	natural gas
18	37%	power purchased from external supplier
6	12%	other:

Have you undertaken any feasibility studies with respect to Arctic power generation?

yes	7	14%
no	42	86%

Are you aware of any such studies by other agencies?

yes	7	14%
no	42	86%

APPENDIX 2: COMPANIES WHO RESPONDED TO THE SURVEY

The following list includes all companies who responded to the survey shown in Appendix 1. Companies are listed alphabetically.

Aber Resources Limited
Bema Gold Corporation/Westview Resources Incorporated
Caledonia Mining Corporation
Cambior Incorporated
Cogema Resources Incorporated
Cominco Limited
Consolidated Pine Channel Gold Corporation
Consolidated Ramrod Gold Corporation
Consolidated Silver Tusk Mines Limited
Continental Pacific Resources Incorporated
Dia Met Minerals
Echo Bay Mines Limited
Falconbridge Limited
Formosa Reources Corporation
Freewest
Goldcorp Incorporated
Hemlo Gold Mines Incorporated
Hudson Bay Exploration and Development Company Limited
INCO Limited
International Vestor Resources Limited
Kasner Group of Companies
Kettle River Resources Limited
Leeward Capital Corporation
Lumina Investment Corporation
Metall Mining Corporation
Noble Peak Resources
Noranda Minerals
North American Metals Corporation
Pacific Comox Resources
Pacific Sentinel Gold Corporation
Placer Dome Canada Limited
Queenston Mining Incorporated
Rea Gold Corporation
Rhonda Mining Corporation
Rio Algom Exploration Incorporated
Royal Oak Mines Incorporated
St. Andrew Gold Corporation
San Andreas Resources Corporation
Skeena Resources Limited
Stratabound Minerals Corporation
SouthernEra Resources Limited
Thunderwood Resources Incorporated
Toscana Reources Limited

United Keno Hill Mines Limited
Viking Yellowknife Gold Mines Limited
Western Copper Holdings Limited
Westley Technologies Limited
Westmin Resources Limited
YGC Resources Limited

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